

AGRICULTURAL ENGINEERING

The Journal of the American Society of Agricultural Engineers

JUNE 1928

Substitutes for Breakpins—Drawbar
Springs *E. G. McKibben*

The Effect of Drainage on Forest
Growth *Raphael Zon and J. L. Averell*

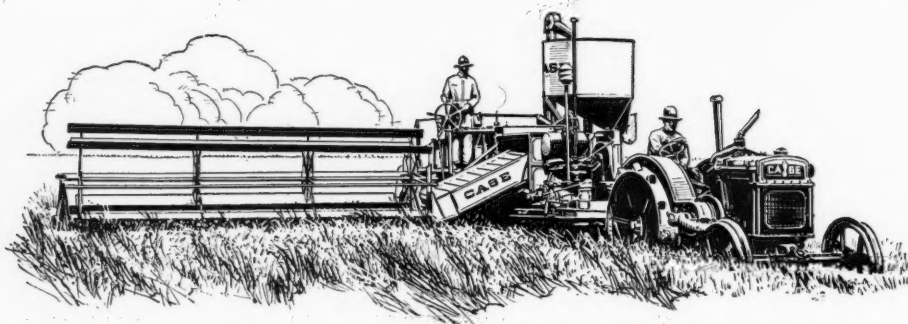
Machinery Reduces Farm Production
Costs *H. R. Tolley*

Ensilage Cutting Results With Elec-
tric Motors *E. A. Stewart*

Recent Progress in Earth Wall Con-
struction *J. D. Long*

Relation of Dairy Cow's Environment
to Housing *M. A. R. Kelley*





An Old Idea Brought Up To Date

THE harvesting and threshing of grain at one operation is by no means a new idea. The first machine of record was invented in 1828. The combine, in one form or another, has been in use in some localities for many years.



Established
1842

The Sign of
Outstanding
Quality in—

Tractors
Threshers
Combines
Silo Fillers
Hay Balers
Skid Engines

Also—
Grand Detour
Plows and
Tillage Tools

It remained for this Company, with its years of rich experience in threshing grain under all known conditions, to develop and produce a highly efficient, economical, durable combine that is being used profitably wherever combining is practical.

Threshing with a machine moving over rough fields, going up and down grades at varying rates of travel; at times threshing the heads only and at other times taking in the full length of straw, perhaps mixed with rank weeds—this is the big problem in combining. Case experience and Case efficiency solved this problem and gave to grain growers a machine that greatly increased their earning capacity.

J. I. Case Threshing Machine Co., Inc.
Dept. F-58 RACINE WISCONSIN

NOTE—Our plows are NOT the
Case Plows made by the J. I.
Case Plow Works Co.

CASE

AGRICULTURAL ENGINEERING

Published monthly by the American Society of Agricultural Engineers
Publication Office, Bridgman, Michigan. Editorial and Advertising Departments at
the Headquarters of the Society, Saint Joseph, Michigan

Subscription price to non-members of the Society, \$3.00 a year, 30 cents a copy; to members of the Society, \$2.00 a year, 20 cents a copy. Postage to countries to which second-class rates are not applicable, \$1.00 additional. Entered as second-class matter, October 8, 1925, at the post office at Bridgman, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921. The title AGRICULTURAL ENGINEERING is registered in the U. S. Patent Office.

O. B. ZIMMERMAN, President

RAYMOND OLNEY, Secretary-Treasurer

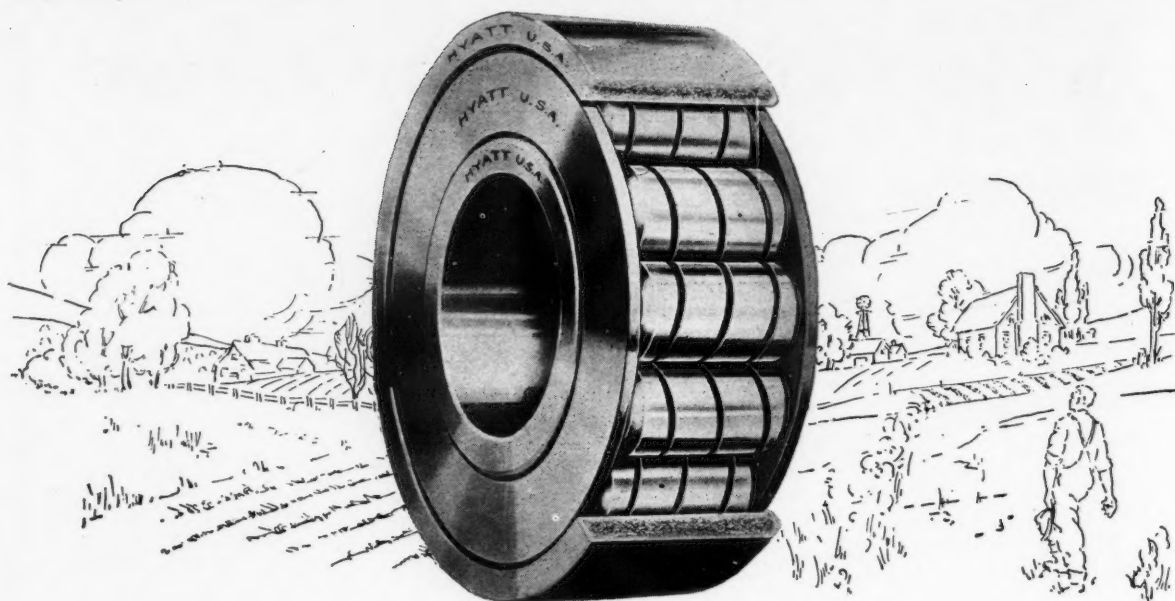
Vol. 9

JUNE, 1928

No. 6

CONTENTS

SUBSTITUTES FOR BREAKPINS—DRAWBAR SPRINGS	167
By E. G. McKibben	
THE EFFECT OF DRAINAGE ON FOREST GROWTH	171
By Raphael Zon and J. L. Averell	
THE USE OF MACHINERY IN REDUCING FARM PRODUCTION COSTS	173
By H. R. Tolley	
CUTTING ENSILAGE WITH ELECTRIC MOTORS	175
By E. A. Stewart	
LABORATORY TESTS OF ORCHARD HEATERS	179
By A. H. Hoffman	
HAY HOISTS PROVE PRACTICAL IN WASHINGTON	180
By Harry L. Garver	
THE STATUS OF FARM FIRE PREVENTION	182
By I. D. Goss	
PROGRESS IN EARTH WALL CONSTRUCTION.....	183
By J. D. Long	
EFFECTS OF ENVIRONMENT ON THE DAIRY COW AND ITS RELATION TO HOUSING	186
By M. A. R. Kelley	
VIRGINIA PAYS TRIBUTE OF HONOR TO McCORMICK	189
AGRICULTURAL ENGINEERING DIGEST	192
EDITORIALS	194
—No Bigger Than Its Engineering	
—Our Field	
—Early Uses	
WHO'S WHO IN AGRICULTURAL ENGINEERING	195
A.S.A.E. AND RELATED ACTIVITIES	196



Giving Them Their Money's Worth

FARMERS are educated to look for improvements—not merely in external appearance, but in the unseen parts—parts which mean the difference between profit or loss in the every day operation of their equipment.

When these vital parts of a machine are Hyatt protected, the farmers realize that the builder has been just as exacting in all details of design and selection of materials.

Hyatt Roller Bearing equipment makes good machinery better. Now is the time to consider the application of Hyatts for all your newer designs.

You can depend on these sturdy bearings to give the same measure of satisfactory service they have rendered for the past thirty-seven years.

HYATT ROLLER BEARING COMPANY

Newark Detroit Chicago Pittsburgh Oakland

HYATT

ROLLER BEARINGS

PRODUCT OF GENERAL MOTORS

AGRICULTURAL ENGINEERING

Vol. 9

JUNE, 1928

No. 6

Substitutes for Breakpins—Drawbar Springs¹

By E. G. McKibben²

THE possibilities of the drawbar spring are worthy of careful consideration by any agricultural engineer interested in the use of mechanical power for farm traction purposes. This is particularly true because of the present tendency to increase the speed of tillage operations, and because of the reluctance of the average operator to use any type of complete overload release unless soil conditions make it absolutely necessary. It is quite common to replace wooden breakpins with bolts and to either remove or clamp spring overload releases. While the use of a drawbar spring is not a cure-all, and under certain conditions can not replace the breakpin or other methods of complete release, there are conditions under which it can replace the breakpin; under most conditions it would reduce the frequency of breakpin replacement and increase the life of both tractor and implement.

The drawbar spring has the following advantages:

1. Its action is uniform and dependable.
2. It reduces the force applied to the implement and tractor, as the result of a sudden increase in speed or load resistance.
3. In comparison with breakpins or special release hitches, it requires practically no attention or replacement.

The following are some of the disadvantages and shortcomings of the drawbar spring:

1. It adds slightly to the first cost.
2. It is probably not practical to depend entirely on a drawbar spring for overload protection where tillage implements are used at high speeds.
3. It can not be used to protect a light implement which is being pulled by a large tractor where the

drawbar pull due to traction alone is greater than the safe load for the implement.

Kinetic Energy of a Moving Tractor. According to the well-known formula for the kinetic energy of a moving body, the kinetic energy stored in a moving tractor is proportional to the square of its speed. Table I and Fig. 1 illustrate the quantity of energy stored in a moving tractor and the effect of even a small increase in speed. They were obtained by substituting the proper value in the following formulas:

$$\text{Mass} \times \text{Velocity}^2$$

$$\text{Kinetic Energy} = \frac{2}{12 \times 5280 \times W S^2}$$

If S = Speed of tractor in miles per hour,
and W = Weight of tractor in pounds,

$$12 \times 5280 \times W S^2$$

Then $\frac{2 \times 32 \times 60^4}{12 \times 5280 \times W S^2} = 0.4008 W S^2 = \text{Kinetic energy of}$

tractor in inch-pounds.....(1)

From Equation 1 and the corresponding table and figure it is evident that the kinetic energy stored in a moving tractor becomes a very serious problem in the operation of tillage implements at high tractor speeds.

Table I. Effect of Speed on Kinetic Energy of Tractor

SPEED (Miles per hour)	KINETIC ENERGY (Inch-pounds per lb. of tractor weight)
1	0.40
2	1.60
3	3.61
4	6.41
5	10.02
6	14.43
7	19.64
8	25.65
9	32.46
10	40.08

Potential Energy of a Drawbar Spring. In the following analysis of the energy absorbed by the spring and other parts of the drawbar, hitch and implement, it is assumed,

¹Second of a series of three articles on substitutes for breakpins. The first article, entitled "Results of a Study of the Strength of Wooden and Metal Breakpins," by A. H. Hoffman, appeared in the May issue of AGRICULTURAL ENGINEERING. The third article, by Mr. McKibben, on spring release hitches will appear in an early issue.

²Assistant agricultural engineer, University of California. Mem. A.S.A.E.

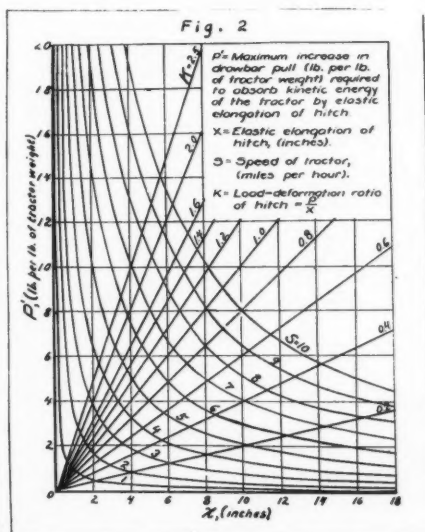
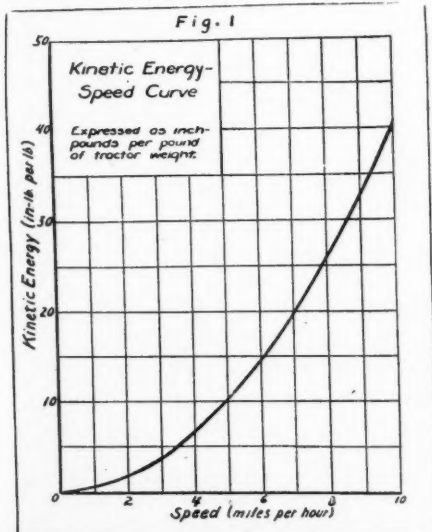
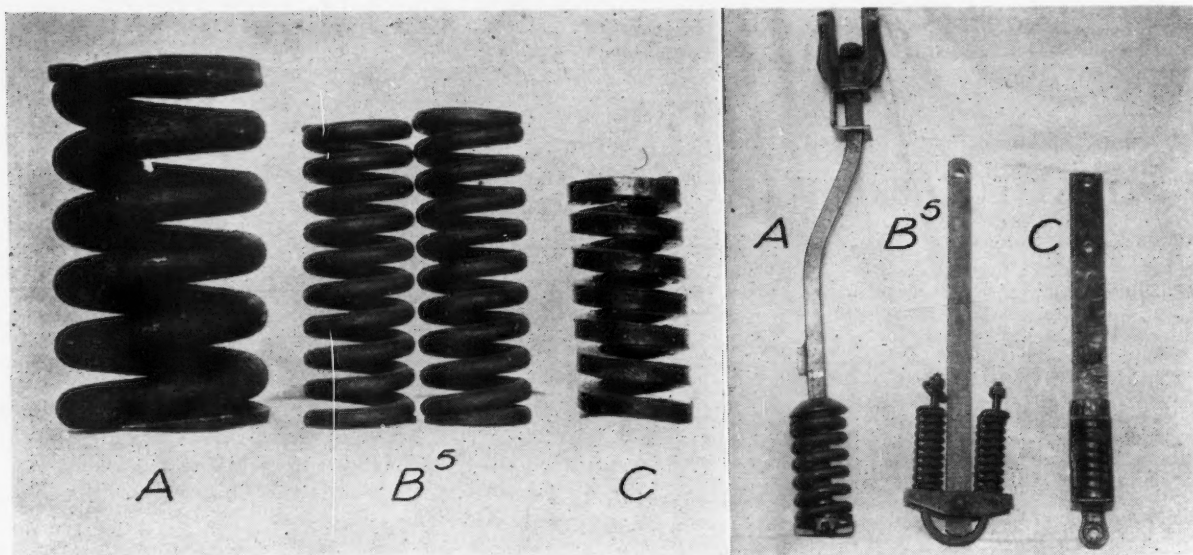


Fig. 1. (Left) This graph illustrates the quantity of kinetic energy stored in a moving tractor and the effect of even a small increase in speed

Fig. 2. (Right) From this chart it is possible to obtain the approximate relationship between weight, speed and tractive ability of tractors and load-deformation ratios of drawbar springs



Figs. 3 and 4. Three typical drawbar springs

first, that the implement is stopped instantaneously (This is the worst possible situation and one which would be approached as a limit in case a tillage implement struck squarely against a very large rock); and, second, that no part of the hitch is stressed beyond the elastic limit (given a permanent set). Under these conditions the increase in the drawbar pull, due to the sudden stopping of the tractor, will be proportional to the deformation, that is, elongation of the hitch.

Thus, if P = the increase in the drawbar pull above tractive ability² due to the sudden stopping of the tractor, in pounds,

$P' = \frac{P}{W}$, or the increase in the drawbar pull above tractive

ability due to the sudden stopping of the tractor, in pounds per pound of tractor weight,

and x = the elastic elongation of the hitch or deformation of the drawbar spring in inches, due to P ,

then $\frac{Px}{2}$ = the increase in the potential energy stored in the hitch and spring, in inch-pounds, (2)

and $\frac{P'x}{2}$ = the increase in the potential energy stored

in the hitch and spring in inch-pounds per pound of tractor weight.

Relation Between Kinetic Energy of Tractor and Potential Energy of Spring. If the tractor is stopped under the conditions stated above, the increase in the potential energy stored in the drawbar spring will be equal to the kinetic energy of the tractor. From equations 1 and 2

$$\frac{Px}{2} = 0.4008 WS^2 \quad (3)$$

Solving Equation 3 for P

$$P = \frac{0.8016 WS^2}{x} \quad (4)$$

This equation expresses the relation between the weight, W , of a tractor, its speed, S , the distance, x , in which it is stopped by elastic elongation of the hitch, and the resulting increase, P , of the drawbar pull above the maximum tractive ability.

²By tractive ability is meant the maximum possible drawbar pull, due to traction alone, for the given tractor under the given conditions.

If P' is substituted for $\frac{P}{W}$, Equation 4 becomes

$$P' = \frac{0.8016 S^2}{x} \quad (5)$$

Table II was obtained by substituting the proper values in Equation 5. This table indicates the excessive forces which may result from the sudden stopping of a tractor. Thus if a tractor weighing 5,000 lb. were stopped by a spring from a speed of 5 mi. per hr. in a distance of 0.1 in., the increase in the drawbar pull would be over 1,000,000 lb., or 500 tons. The whole situation is pictured by Fig. 2 which is explained below.

TABLE II. Increase⁴ in Drawbar Pull Above Tractive Ability of Tractor, Due to Sudden Stopping of Implement, Expressed as Pounds Per Pound of Tractor Weight

Elastic Elongation of hitch (in.)	SPEED (miles per hour)					
	1	2	3	4	5	10
0.1	8.02	32.06	72.14	128.26	200.40	801.60
0.2	4.01	16.03	36.07	64.13	100.20	400.80
0.5	1.60	6.41	14.43	25.65	40.08	160.32
1.0	0.80	3.21	7.21	12.83	20.04	80.16
2.0	0.40	1.60	3.61	6.41	10.02	40.08
3.0	0.27	1.07	2.41	4.28	6.68	26.72
4.0	0.20	0.80	1.80	3.21	5.01	20.04
5.0	0.16	0.64	1.44	2.57	4.01	16.03
6.0	0.13	0.53	1.20	2.14	3.34	13.36
7.0	0.11	0.47	1.03	1.83	2.86	11.45
8.0	0.10	0.40	0.90	1.60	2.51	10.02
9.0	0.09	0.36	0.80	1.43	2.23	8.91
10.0	0.08	0.32	0.72	1.28	2.00	8.02
11.0	0.07	0.29	0.66	1.17	1.82	7.29
12.0	0.06	0.27	0.60	1.07	1.67	6.68
15.0	0.05	0.21	0.48	0.86	1.34	5.34
18.0	0.04	0.18	0.40	0.71	1.11	4.45

⁴Assuming, first, that the implement is stopped instantaneously, and, second, that the elongation of the hitch is proportional to the drawbar pull. The former represents the worst possible condition which would be approached as a limit if the implement encountered a very hard and rigid obstruction. The latter will be approximately true unless some part of the hitch is stressed beyond the elastic limit and given a permanent set.

Since within the operating range of any given spring, its load-deformation ratio, $\frac{P}{x}$, is practically constant it simplifies the analysis of the behavior of a given spring to represent this constant by "k."

$$\text{Thus } k = \frac{P}{x} \dots\dots\dots (6)$$

Also since the power of a tractor and the strength of the implement used with it is usually more or less proportional to the weight of the tractor, it simplifies the general application of the principles involved to represent the relation between P , W , and x by the constant, K .

$$\text{Thus } K = \frac{P}{Wx} = \frac{P'}{x} \dots\dots\dots (7)$$

Solving Equations 6 and 7 for x , and substituting these values of x in Equation 4,

$$P = S \sqrt{0.8016 Wk} \dots\dots\dots (8)$$

$$P' = S \sqrt{0.8016 K} \dots\dots\dots (9)$$

These equations express the relation between the weight, W , of a tractor, its speed, S , and the increase, P , or P' in the drawbar pull, above tractive ability, resulting from stopping by an elastic hitch whose load-deformation is k or K .

Likewise solving Equations 6 and 7 for P and substituting these values of P in Equation 4,

$$x = S \sqrt{\frac{0.8016 W}{k}} \dots\dots\dots (10)$$

$$x = S \sqrt{\frac{0.8016}{K}} \dots\dots\dots (11)$$

These equations express the relation between the weight, W , of a tractor, its speed, S , and the distance, x , in which it will be stopped by an elastic hitch whose load-deformation ratio is k , or K .

Since the spring is subjected to the tractive force, T , of the tractor, as well as the acceleration forces, P , if the spring is not to be completely compressed and thus fail to absorb all of the kinetic energy of the tractor, its strength must be such that the force, F , required to compress it is

$$F = T + P, \text{ or } F > T + P \dots\dots\dots (12)$$

If $F < T + P$, the spring will absorb only a part of the kinetic energy of the tractor; and other parts of the drawbar, hitch, or implement must either absorb the remaining kinetic energy by elastic or permanent deformation or be broken.

If under given conditions a spring will absorb the tractive and inertia loads of a given tractor up to a certain speed, S_1 , and the tractor is operated at a higher speed, S_2 , the effect is approximately as if the tractor were operated without the spring at speed, S_2 , where,

$$S_2 = \sqrt{S_1^2 - S_1^2} \dots\dots\dots (13)$$

Drawbar Spring Chart. Fig. 2 is a graphic representation of Equations 5, 9 and 11. By the use of such a chart it is possible to obtain quite easily and quickly the approximate rela-

tionship between weight, speed and tractive ability of tractors and the load deformation ratios, K , of drawbar springs.

Thus, if a tractor weighing 5,000 lb. were stopped from a speed of 1 mi. per hr. by a spring in a distance of 2 in. the increase in drawbar pull would be approximately 0.4 times the weight of the tractor or about 2,000 lb. The load deformation ratio, K , of the required spring would be 0.2. That is, a load of 0.4 times the tractor weight, or in this case 2,000 lb. would cause a deflection of 2 in. If the maximum tractive ability of the tractor were 0.8 times its weight, or 4,000 lb., the spring would have a maximum deformation of not less than 6 in., and the total drawbar pull would be 6,000 lb.

If with this tractor weight, tractive ability and load-deformation ratio of spring, the maximum deformation of the spring were 10 in., it would absorb the kinetic energy of the tractor up to 3 mi. per hour. If under these conditions the tractor were operated at 5 mi. per hr., the situation would be the same as if the tractor were operated at 4 mi. per hr. without the spring in the drawbar.

The same sort of analysis may be made for any situation which is within the range of the chart. Of course, if a chart were to be used in actual design, it would need to be made much larger with many more coordinate lines and curves.

Also this chart illustrates clearly the difficulties which will be encountered in any attempt to increase tillage speeds where stones, stumps or other obstructions are frequent.

Sudden Acceleration of the Implement. Due to the inertia force resulting from sudden acceleration of the weight of the implement, sudden engagement of the clutch, particularly where the slack has not been taken out of the hitch, may result in increased stress on the hitch and certain implement parts even though no unusual soil condition has been encountered. In this case the same principles apply. However, since the weight of the implement is usually much less than that of the tractor, this situation is much easier to handle with a drawbar spring.

Some Typical Drawbar Springs. Three typical drawbar springs² are shown in Figs. 3 and 4. Their load-deformation ratio was determined by the use of a Riehle tension-compression machine. The results along with descriptive measurements are given in Table III.

Fig. 5 shows the increase in drawbar pull which would result from the sudden stopping of these tractors provided the sum of the tractive and inertia forces did not exceed the strength of the spring.

Fig. 6 shows the speeds at which the springs would be fully compressed by sudden stopping with varying condition of tractive ability.

²Two springs were used in parallel in this drawbar; the dimensions given apply to the individual springs, while the loads given apply to the two used as a unit.

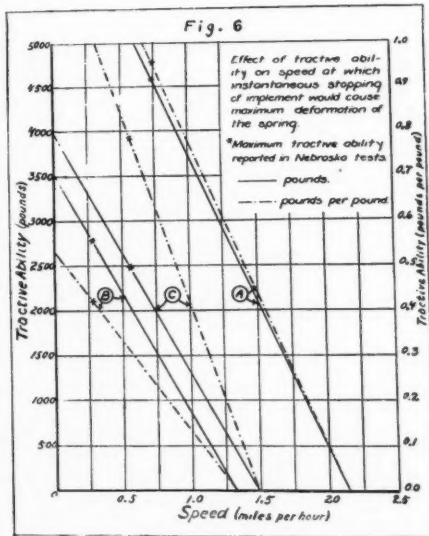
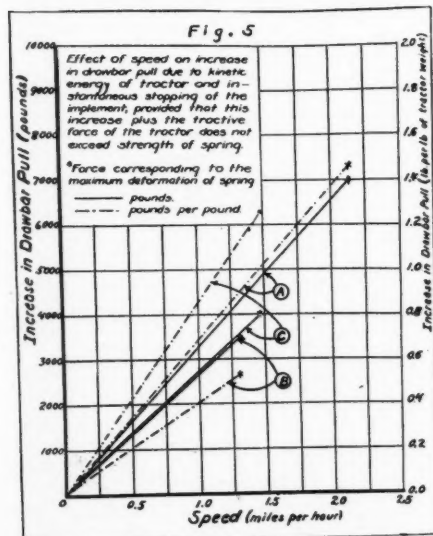


Fig. 5. (Left) Graph showing the increase in drawbar pull which would result from the sudden stopping of tractors, provided the sum of the tractive and inertia forces did not exceed the strength of the spring

Fig. 6. (Right) Graph showing the speeds at which the springs would be fully compressed by sudden stopping with varying conditions of tractive ability

From these figures the following conclusions may be drawn:

1. At normal speed of 1.5 to 2.5 mi. per hr. and maximum tractive ability of from 40 to 90 per cent of the tractor's weight, these springs would not protect the implement against excessive stresses in case relatively solid obstructions were encountered.

2. From the standpoint of affording protection to the implements all three springs should have a much greater possible deformation, that is, be longer; likewise all three should be stiffer. The latter is particularly true of spring B.

Of course, unless the tractive ability of the tractor is greater than that load required to completely compress the spring, it will decrease the stress resulting from sudden stopping, even though it is not able to absorb all of the kinetic energy of the tractor.

TABLE III. Description of Springs Studied

Number of spring	A	B ^a	C
Material shape	Round	Round	Square
Size (inches)	0.875	0.438	0.500
Pitch or lead (inches)	1.375	0.750	0.800
Pitch diameter (inches)	3.875	2.063	2.000
Free length (inches)	8.250	7.000	5.500
Compressed length (inches)	5.750	4.400	4.100
Maximum deformation (inches)	2.500	2.600	1.400
Maximum load (pounds)	7000	3500	4000
Load ÷ Deformation	2800	1347	2857
Weight of tractor (pounds)	4775	6640	3175
Load ÷ Weight of tractor x Deformation	0.586	0.203	0.900

^aTwo springs were used in parallel in this drawbar; the dimensions given apply to the individual springs, while the loads given apply to the two used as a unit.

CONCLUSIONS^a

1. A properly selected drawbar spring can give satisfactory and constant protection at low and medium tractor speeds if the implement will stand a drawbar pull of 1.5 to 2 times the maximum tractive ability of the tractor.

2. At higher tractor speeds it is probably not practical to replace the breakpin by use of a drawbar spring, although a sulking from a sudden increase of speed or load; and thus properly selected drawbar spring will reduce the stress re-should reduce the frequency of breakpin replacement.

3. Even the best of drawbar springs can afford little protection for a light implement which is pulled by a heavy tractor, for which it is not designed.

4. By the use of a chart similar to Fig. 2 the relationship between the weight, speed, and tractive ability of a tractor, and the load-deformation ratio of a drawbar spring can be quickly and easily obtained.

5. The kinetic energy of a moving tractor varies as the square of its speed. (Note Equation 1, Table I, and Fig. 1.)

6. If the hitch is comparatively rigid an enormous drawbar pull may result from the sudden stopping of an implement by a relatively solid obstruction. (Note Equation 4, Table II, and Fig. 2.)

7. Provided it is strong enough so as not to be completely compressed the effectiveness of a given spring in preventing excessive increase in the drawbar pull varies as the value of $[S \sqrt{Wk}]$. (Note Equation 8.)

8. For a given tractor and spring, the maximum increase in the drawbar pull, and the corresponding deformation of the spring due to the sudden stopping of the tractor will vary as the speed of the tractor.

9. For a given speed of tractor the maximum increase, P' in the drawbar pull due to the sudden stopping of the tractor will vary as the square root of the load-deformation ratio, K , of the spring, and the corresponding deformation of the spring will vary inversely as the square root of the load-deformation ratio of the spring.

10. For a given allowable increase in drawbar pull due to a sudden stopping of the tractor the load deformation ratio, K , of the required spring will vary inversely as the square of the speed, and the corresponding deformation of the spring will vary as the square of the speed.

^aIn these conclusions, unless otherwise stated, it is assumed, first, that the drawbar spring is strong enough to prevent complete deformation, and, second, that the increase in drawbar pull is the increase above the maximum tractive ability of the tractor.

11. For a given allowable deformation of spring the load-deformation ratio, K , of the required spring and the corresponding maximum increase in the drawbar pull due to the sudden stopping of the tractor will vary as the square of the speed of the tractor.

12. For a given spring and speed of tractor the maximum increase in the drawbar pull due to the sudden stopping of the tractor and the corresponding deformation of the spring will vary as the square root of the weight of the tractor.

13. For a given spring and a given allowable deformation or increase in drawbar pull due to the sudden stopping of the tractor, the allowable speed will vary inversely as the square root of the weight of the tractor.

14. For a given speed and a given allowable increase in the drawbar pull due to the sudden stopping of the tractor, the load-deformation ratio, k , of the required spring will vary inversely as the weight of the tractor, and corresponding deformation of the spring will vary as the weight of the tractor.

15. For a given speed and a given allowable deformation, the load-deformation ratio, k , of the weakest allowable spring and the corresponding maximum increase in drawbar pull will vary as the weight of the tractor.

16. For a given allowable deformation and given allowable increase in pull due to the sudden stopping of a tractor the greatest allowable speed varies inversely as the square root of the weight of the tractor.

Tractors Aid in Flood Disaster

THE breaking of the St. Francis dam in California wrought havoc in one of the richest farming areas in the world.

About 29,000 acres of oranges, walnuts and lesser orchard land was swept over by the 12 billion gallons of water let loose in a wall of water that started at a height of 175 feet and swept 50 miles to the sea, killing more than 400 humans and doing upwards of \$20,000,000 property damage.

Yet the fruitful valley of the Santa Clara River is showing an astonishing resourcefulness and speed in reconstruction and rehabilitation. More than 200 tractors are at work, a mobilized mechanical army of close to 2,000,000 man power. Most of these tractors were gathered from the farms and ranches of the vicinity.

No other farming area in the world was so highly tractorized as Los Angeles and Ventura Counties, according to census figures. Hence, close at hand, and even in the path of the flood, was a mechanical army ready to start the work of search, reconstruction and rehabilitation at the first word of command. These tractors are engaged in the work of hauling in supplies, tearing apart debris, stringing power cables, salvaging automobiles and trucks, moving houses, building bridges, pulling broken trees, cleaning up orchards and fields, etc., in the flood relief areas.



Three "Caterpillars," working with road rippers, are shown hooking piles of debris from 2 to 8 ft. high deposited among the orange groves of Ventura County

The Effect of Drainage on Forest Growth¹

By Raphael Zon² and James L. Averell³

IN 1926 the Lake States Forest Experiment Station of the U.S.D.A. Forest Service, in cooperation with the U.S.D.A. Division of Agricultural Engineering and the state agricultural colleges of Minnesota, Wisconsin and Michigan, began a study of the effect of the removal of excess water in swamps on timber growth. This was a part of a broader study, namely, the management of swamp forests in the lake states.

The swamp problem presents many phases which are being taken up in the course of the study covered by the following outline:

1. Classification of the swamps on the basis of their origin, topography of the bed, depth of peat, and their feasibility to drainage.
2. The physical conditions of the soil affecting the growth of forest trees in swamps, such as its structure, temperature, acidity, aeration, bacterial activity, degree of decomposition of peat, and availability of nutritive elements.
3. The effect of superficial drainage on the physical conditions of the soil, and, therefore, upon the growth itself; effect of the degree of drainage on the diameter, height and volume growth; distance from the ditch at which the effect of drainage is observed; effect of drainage on trees of different ages, degrees of suppression and vigor of growth; effect of drainage on natural reproduction and thickening up of the stand.
4. The technique of drainage—clearing out streams, protection ditches for intercepting surface run-off from surrounding high land, and main and lateral ditches; different methods of drainage, work and cost.
5. Comparative revenue from increased growth and the cost of ditching. Yield per acre of different species before and after draining.
6. Effect of thinnings upon the growth of swamp forests.
7. Special methods necessary for planting drained swamps to forest trees.

Method of Approach. This comprehensive plan has been approached in two ways. First, a study was made of swampy areas which were drained for agricultural purposes to determine the effect it had on any timber there might be on it. The second step was to undertake drainage under controlled conditions and study the effect of different methods of drainage on timber growth.

Results of Observational Method. As an example of the first method of investigation may be cited the Williams

Swamp in Minnesota, lying 15 mi. northwest of Duluth. It was drained in 1918 by parallel ditches and laterals about 600 ft. apart. The main ditches were from 4 to 5 ft. deep and 3 ft. wide at the bottom, with the laterals somewhat smaller.

This drainage had reduced the water level from close to the surface, where it stood most of the year, down to 2 or 3 ft. beneath. Being a Sphagnum-covered swamp bearing an open stand of stunted tamarack and black spruce, the precipitation was easily absorbed and held by the moss, preventing the occurrence of bone-dry conditions. Yet in this particular instance, the form of the swamp, the type of the peat, and the position of the ditches were so in accordance with the ameliorative need of the trees, that marked increase in growth occurred the year after ditching.

Ten trees were cut and analyzed to determine the growth before and after drainage. The results are shown in Table I. Both tamarack and black spruce responded to the improved growing conditions, even though growing on peat varying in depth from 7 to 15 ft. An outstanding example of the extreme which can be hoped for in such drainage improvement work is tree No. 1 (Table I)—a tamarack which was 10 ft. high and 1.13 in. in diameter at the time of drainage. Seven years later it had more than doubled its dimensions, being 20 ft. high and 2.60 in. in diameter, thereby increasing its volume by over 100 per cent per year. If drainage had not occurred, the computed probable dimensions of this tree would have been only 11 ft. high and 1.26 in. in diameter, a typically insignificant rate of growth for "drowned" forest trees.

The distance from tree No. 1 to the ditch was 225 ft. which accentuates its phenomenal response to drainage. By studying such extreme cases found in drainage attempts, whether they are extremely good as in this case, or extreme-bad as often happens, it is hoped to bring out some of the controlling factors.

Another instance of improved growth was found on the Northeast Experiment Farm at Grand Rapids, Minn. Here in 1910 a tile drainage system was laid through a peat bog to lower the water level for experimental farming. The cut for the drains was from 2 to 4 ft. deep. The swamp was a typical bowl-shaped Sphagnum bog of northern Minnesota, covering 20 acres with peat 22 ft. deep in the center. The scattered clumps of black spruce and tamarack were cleared from only a portion of the drained area, so that an opportunity for observations on tree growth was possible. This was done in 1925, fifteen years after the tile was laid.

A typical black spruce which was 12 ft. tall and 0.80 in. in diameter in 1910 was found to be 18 ft. tall, with a diameter of 2.80 in. in 1925; an increase in volume of 92 per cent. A typical tamarack which was only 2½ ft. tall

TABLE I. Growth Record of Trees from Williams Swamp

Tree No.	Species	Depth of peat	Distance from ditch	Time of ditching	Dimension of tree at time of drainage (1918)			Age	Dimension of tree in 1925									Difference between probable and actual volume	Per cent per year	Rate of volume growth per yr.			Difference between probable and actual diameters
					Diameter inside bark	Height	Volume		Probable			Actual			without drainage	with drainage							
									Age	Diameter	Height	Volume	Diameter	Height			Volume						
		ft.	ft.	1918	in.	ft.	cu. ft.		Age	Diameter	Height	Volume	in.	ft.	cu. ft.	cu. ft. %		cu. ft.	cu. ft.	in.	%	%	
1	Tamarack	7.5	225	1918	1.13	10.0	0.0365	49	56	1.26	11.0	0.0467	2.60	20.0	0.3793	0.3326	712.2	101.7	0.0015	0.0490	1.34	106.0	15.1
2	Tamarack	7.5	225	1918	0.39	3.5	0.0014	11	18	0.67	5.5	0.0067	1.57	13.0	0.0134	0.0067	100.0	14.3	0.0008	0.0017	0.90	134.3	19.2
3	Tamarack	9.5	225	1918	0.82	4.5	0.0083	41	48	1.00	6.0	0.0163	1.36	12.0	0.0606	0.0443	272.4	38.9	0.0011	0.0075	0.36	36.0	5.1
4	Tamarack	9.5	225	1918	1.25	7.0	0.0280	67	74	1.33	9.0	0.0414	1.57	13.0	0.0910	0.0496	119.8	17.1	0.0019	0.0090	0.24	18.0	2.6
5	Tamarack	12.9	130	1918	1.38	7.0	0.0364	53	60	1.67	9.0	0.0675	2.34	14.0	0.2093	0.1418	210.1	30.0	0.0044	0.0247	0.67	40.1	5.7
6	Black spruce	12.9	130	1918	0.84	4.5	0.0087	31	38	1.00	5.0	0.0136	1.77	10.0	0.0850	0.0714	525.0	75.0	0.0007	0.0109	0.77	77.0	11.0
7	Black spruce	12.9	180	1918	0.80			19	26	1.05			1.52								0.47	44.8	6.4
8	Tamarack	12.9	180	1918	1.17			36	43	1.40			2.22								0.82	58.6	8.4
9	Tamarack	14.6	140	1918	0.60			14	21	0.68			1.52								0.84	123.5	17.6
10	Tamarack	14.6	140	1918	0.67			31	38	0.83			1.52								0.69	83.1	11.6

¹Paper presented before the annual meeting of the National Drainage Congress, at Kansas City, March, 1928.

²Director, Lake States Forest Experiment Station, U. S. Department of Agriculture.

³Junior forester, Lake States Forest Experiment Station, U. S. Department of Agriculture.

at the time of drainage, grew in the 15 years to a tree 24 ft. tall and 3½ in. in diameter.

Such cases, as found on these two areas, are encouraging evidence that under certain conditions swamp trees will substantially increase their growth with drainage. However, the ubiquitous drainage attempt, both in this country and Europe, which has failed to accelerate the tree growth, incites one to caution when studying this problem.

Drainage under Controlled Conditions. The second step, of ditching certain swamp areas for experimental drainage under controlled conditions, was undertaken after a number of locations were examined. The two finally chosen and ditched were a black spruce-Sphagnum swamp in northern Minnesota, 30 mi. east of Cass Lake, and a cedar swamp in the Upper Peninsula of Michigan, 25 mi. southeast of Marquette.

In the Minnesota swamp we have a good example of a bowl-shaped type of swamp supporting a scattered stand of black spruce. (Fig. 1.) It is about 1500 ft. long, 500 ft. wide, and 13 ft. at its deepest point. The peat is chiefly an open, undecomposed bed of Sphagnum. So-called "girdle" or protection ditches were put around the edge and a main ditch carries the water through the rim and out to where the terrain slopes away, a distance of about 75 ft. beyond the rim. Continuous well readings, before and after drainage, show that the water level has been lowered from its position close to the surface, where it stood most of the year, to a foot below the surface. Since black spruce is a very shallow-rooted species, we hope that this change in water level will be sufficient to show marked improvement in the rate of growth within the next year or two. There are two gates in the ditch system by which the water level

can be still further lowered if needed, or raised if the peat tends to dry out too much. In the graph showing the changed water level due to the ditching of this Minnesota swamp (Graph I), the slight seasonal fluctuation of the water level can be followed. Even after concentrated months of rainfall as occurred in June and August of 1927, it will be noticed that the ditches hold the water level below even the minimum level of 1926. In this experiment, the openness of the peat permits the water to pass quickly through it and into the ditches.

The Michigan swamp, on the other hand, is of a very different character, both in kind of peat and shape of bottom. It is a type that should respond most generously to any drainage of excess water. The soil is a well-decomposed woody peat, about 3 ft. deep, lying on a gradual and uniformly sloping bottom. It is covered with a rather close stand of slow-growing cedar and fir. (Fig. 2.) The natural outlet seems to have been cut off by the paved highway running by, but the accompanying road ditch has prevented surface water from collecting. Good results have not been obtained yet with the ditching system used.

A ten-acre portion of this swamp was selected for study and a single ditch laid through the center in such a way that it empties into the highway drainage system. The well readings in the swamp show that this ditch has not been effective, however. It was expected that the water table would be lowered near the ditch, rising to an unchanged level some distance back on either side. But the graph of the water level 50 ft. from the ditch as compared to that 250 ft. back (Graph II) shows a difference of only a couple of inches, an amount of no practical significance. The

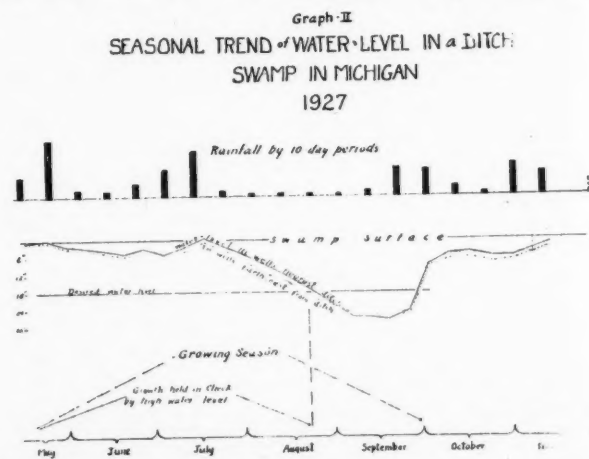
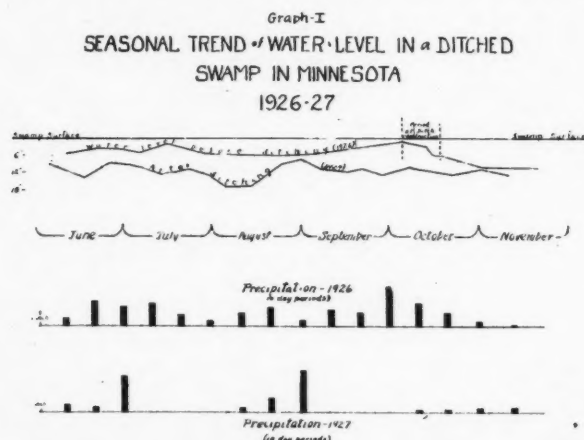


Fig. 1. (Left) Black spruce swamp in northern Minnesota. Pines and birches in background are on highland which forms southern rim of the bowl. Fig. 2 (Right) Cedar swamp in upper peninsula of Michigan. Ditch laid by dynamite



Fig. 3. A peat bog drained for forestry in Finland. Experience has shown that natural seedling will soon cover this area with thrifty young trees

seasonal variation of the water table, however, is about 2½ ft., and its comparison with that in the Minnesota swamp is very marked.

There are several reasons to which the ineffectiveness of this ditch may be attributed. First, the soil where the ditch was laid is a fine woody peat, well decomposed and apparently permits water to pass through only with difficulty. It greatly contrasts with the fibrous and open peat in the Minnesota experiment. Another reason is that no thorough examination was made of the kinds of peat found

in the swamp with an eye to choosing the most fibrous and open deposits, for laying the ditch through, for it is in such places that the swamp water most easily percolates into the drainage system. Possibly the most important reason, however, is that a supplemental experiment was being tried out here, by using dynamite as a cheap means of ditching through wooded swamps. The blasting made a channel about 2 ft. deep, but the ragged shoulders it left and the mudlike quality of the peat has allowed the ditch to partially fill up again, greatly limiting its drainage effectiveness. It is planned, therefore, during the coming field season to improve this ditch and make certain which of these reasons may be the real cause for poor drainage.

When one stops to consider all the possible factors which influence the drainage of swamp land for forest production, there is danger of becoming lost in a maze of details and debatable points. Such involved questions as changes in acidity and toxicity due to drainage, origin and development of swamps as affecting depth of peat and consequently tree growth, types of swamps and peat in regard to ease and effectiveness of ditching, all tend to cloud the issue. The fact remains, however, that most of our remaining supply of spruce pulpwood and cedar poles lies in swamps, and the growth in a large percentage of these wooded swamps is being retarded by excess water. We have plenty of proof, both in this country and abroad, that removal of this excess water by drainage increases the growth of the trees almost immediately. The producing power of entire stands has been increased by three or four times, through drainage (Fig. 3), and open growing stands have given place to thrifty young forests. The investigative work of this station in Minnesota and Michigan and our planned experiments in Wisconsin for this year, will soon serve as examples, we hope, on how to drain with assurance of maximum success.

The Use of Machinery in Reducing Farm Production Costs*

By H. R. Tolley¹

THE use of machinery has been responsible for reducing the production cost of many farm commodities, and there are possibilities of still further reducing costs through a more extended use of machinery, provided the machines are adapted to the conditions under which the work must be done. Even more striking than the reduction in costs has been the increase in output per worker. The output per agricultural worker in this country is now probably three times as great as it was seventy-five years ago, and a large part of this increase has been brought about by the continuous increase in the use of machinery and power. A considerable part of the farm work in the country is still done by hand, however, and another considerable portion is done with small machines and units of power that are far from economical in the use of labor.

Numerous examples could be cited showing how machinery has reduced production costs. One of the most striking of the recent developments is the combined harvester-thresher which has recently come into general use in the Great Plains and which is being extended rapidly eastward. In the Great Plains, grain growers have found that two or three men with a combine can harvest 500 acres easily in a season. The hours of labor required for harvesting and threshing with the combine is only about one-fourth as great as the hours required by the older methods, and, of course, its use results in a very considerable reduction in costs for the men with the large acreages per farm that are common in the West. One must use care, however, in drawing conclusions from the experience of these western men as to the extent to which the combine would reduce costs in other regions where conditions are different and acreages per farm are small.

The tractor affords a similar illustration. Tractors are being used economically and profitably on many farms in all sections of the country. On the other hand, there are a great many farms where two or three horses furnish enough power to get all the work done in good time, and on such farms the tractors that are now available will not often reduce costs or increase incomes.

In the northeastern part of the country, the side-delivery rake and the hay loader are two hay-harvesting machines that do excellent work and save 1½ to 2 hr. of labor per acre. Yet a great many eastern hay growers continue to load their hay by hand, evidently thinking it would not pay to buy a rake and loader. The two machines together cost nearly \$200 and they will probably not last over ten years, and a farmer who hires help for putting up hay would have to use the rake and loader on about 25 to 30 acres of hay a year to save enough in wages to cover depreciation and repairs on the machines and pay interest on his investment. In even the leading hay-producing counties of New York, where 70 to 80 per cent of the crop land is in hay, the average acreage of hay per farm runs only 35 to 40 acres. In most of the counties of both New York and Pennsylvania the average hay acreage per farm is considerably less, and even in the leading hay-producing areas approximately half the farms have a smaller acreage of hay than the average. Thus we see that probably a majority of the hay growers of the East have such small acreages of hay that the use of the rake and loader would not reduce production costs.

Take the elevator potato digger as another example. One of these machines costs about \$150, and under eastern conditions will last probably six to eight years. Compared to digging by hand, it saves a lot of labor, but it will not cover any more ground in a day than the plow type of digger which costs much less and which so many eastern potato growers use. True, the elevator digger leaves all the potatoes on

*Paper presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers, at Philadelphia, Pa., October, 1927.

¹Division of farm management, Bureau of Agricultural Economics, U. S. Department of Agriculture.

top of the ground so that the pickers can work a little more rapidly, but it is evident that one would have to have a rather large acreage of potatoes before the use of the elevator digger would reduce production costs. And picking up the potatoes, the task which takes five times as much labor as the actual digging, must still be done by hand. When we consider that most of the potato growers of the East have five acres or less of potatoes each year, we understand why the elevator digger is not more generally used.

Practically all of the corn grown in the northeastern section of the United States, which is not put in the silo, is cut and shocked, and most of this work is still done by hand. When a corn binder is used it takes about 4 hr. of man labor to cut and shock an acre, while it takes about 6 hr. when the cutting is done by hand. This two hours of labor which the binder saves is worth but little more than the twine which the binder uses. Since a corn binder costs about \$200 and lasts only about 10 years, it is apparent that one would have to have a large acreage of corn in order for the binder to reduce his harvesting costs.

The milking machine is another machine which will reduce costs only on the larger farms. Compared with hand milking the milking machine saves about one hour's work per day for each ten cows in the herd. With a herd of twenty cows the machine will save about 2 hr. of labor per day. An installation for a herd of twenty to twenty-five cows costs in the neighborhood of \$300 and much of the milking on dairy farms is done by unpaid family labor for which there is no other profitable work. These are probably the principal reasons why milking machines are not in more common use.

All of these examples point to the conclusion that much of the machinery that is now available is too expensive to be profitable on many farms as they are now organized. A third of the farms in Pennsylvania and New York are less than 50 acres in size and more than 60 per cent have less than 100 acres. Further, a considerable proportion of the land is usually untillable. Most of these smaller farms, in common with the larger ones, raise corn, small grain and hay, and keep dairy cows, and, in addition, many have some fruit, some potatoes, and other products of minor importance. The sales of products on these smaller farms is not often more than \$2500 a year and in many cases it is not over \$1000. Thus it would be out of the question for the operators to attempt to equip them with tractors, combined harvester-threshers, corn binders, side-delivery rakes and hay loaders, milking machines, potato diggers, and all the other improved machinery which is available.

Many farmers are now using machinery which they know does not reduce their costs or increase their incomes, but which does reduce the amount of hard work they have to do and leaves them and their families more time for leisure and enjoyment. This standard-of-living phase of the use of farm machinery has been one of the important factors in the widespread use of machinery on American farms. As a class, our farmers use more machinery than the farmers of most other nations, and when we take into consideration the nature of the work to be done and the machinery available for doing it, farmers are as progressive as the workers in other industries in adopting machine methods.

The further mechanization of agriculture must await developments in two directions. Machines must be made available that will be economical for the large amount of work for which they are not economical on farms as now organized, or farms must be reorganized so that the machinery now available will be suited to them. With regard to new machinery that can be used profitably on farms as they are now organized, it seems that further developments will be slow. Engineers and manufacturers have been working on the problem for several generations and, while they have made great progress in some directions, after all they have made little headway in providing machinery that can be used economically for much of the work on the small farm.

Many believe that there will be more development in the direction of reorganization of farms so that machines of the types now available, possibly with minor modifications, can be used more advantageously. This will mean, first of all, larger farms, and consequently a larger production and larger gross income per farm. From the standpoint of the welfare of farmers as a class this is a development much

to be desired. Too many farmers are now operating on such a small scale that, even with the most rigid economy in production, their incomes will not be sufficient to allow them more than a very moderate standard of living. This trend toward larger farms may also be accompanied by a reduction in the number of lines of production on a particular farm and more attention given to the products for which the farm and the farmer are best suited. On this point, Dr. G. F. Warren, of Cornell University, recently said:

"The whole history of American agriculture shows increasing specialization on those products best adapted to the region.

"The increase in scientific knowledge and technical skill favors the production of a few products. Machinery also favors specialization. To equip for a small area of any one crop is too expensive. Improved transportation enlarges the market for the region that has a natural advantage. The farmers are gradually specializing on the product for which their region has the advantage. Some persons still insist that their home region is best for everything, but competition is gradually replacing false patriotism by knowledge.

"Many well-meaning persons think that the trouble with agriculture is lack of diversity. They forget the agricultural history of the past century."

The tendency toward a larger acreage per farm is also apparent. In all parts of the country, aggressive, foresighted farmers can be found who are acquiring enough land and equipment to make the most efficient unit for the type of farming which they are following.

Developments in this direction will result in enlarging the output per worker in agriculture and will make it necessary for many who are now farming to seek other occupations, or, as it is sometimes stated, will release a large number of workers from agriculture to other industries. There is a possibility of the demand for agricultural products increasing so that the total production could be increased with profit to those engaged in farming, but those who are concerned with finding markets for agricultural products seem to be confronted with more or less chronic surpluses of most commodities. An increased demand for food products, taken all together, within the United States will be definitely limited to the increase in population, and those who have studied the situation in foreign countries see little likelihood of a demand for any very materially larger amount of American agricultural products at prices that would be attractive to American farmers. Thus the immediate benefits which would come to farmers generally from a largely increased use of machinery and power seems to depend upon the ease and celerity with which the farmers and farm workers, who would be "released" by the machines, could find other occupations.

Finally, it should be remembered that, because of the conditions prevailing at the time many of our present agricultural communities were settled, much of the land and many of the farms now in operation in those areas are not adapted to a type of agriculture where machine methods of production play a dominant role. In many old settled areas, particularly in the eastern half of the United States, the topography of much of the farm land precludes the use of many types of modern farm machinery. Fields are often inevitably small, and the noncontiguous character of the small areas of good farming land available precludes the possibility of overcoming the handicap of small farms by combining them into larger farms. In many of these areas which were thickly settled in advance of the development of the more fertile lands farther west, which are also better adapted to the use of modern machine methods of farming, conditions have so changed since the time of their settlement that it is now very difficult for farmers to make incomes large enough to justify them remaining in the farming business. Soils, topography, size of fields, size of farms, location with respect to market or other factors are often such that the farmers of these areas do not have any special advantage in the production of any commodities. Undoubtedly, one of the results of the greater use of machinery on farms where conditions for its use are favorable would be to increase the difficulties of farmers who, because of the natural conditions with which they must work, are not able to adopt similar methods.

Cutting Ensilage With Electric Motors¹

By E. A. Stewart²

Part I. Elevation Theory and Practice

WHEN an ensilage cutter is operated at a very low speed it is a familiar fact that the pipe has a tendency to clog with ensilage. This tendency is also noted when an ensilage cutter is run at fairly high speed. Quite frequently it is recommended to farmers, where they have been having trouble with the pipe clogging with ensilage, to run the cutter somewhat slower. This has been effective in a great many cases. On the other hand, when we reduce the speed of the cutter as low as 330 r.p.m. and below, we find that the blower has a tendency to plug under two very peculiar conditions.

These two conditions are: First, when the machine was running with a very heavy load and the machine started to slow down to some extent, the instant the feeding apron would stop the pipe appeared to plug while the corn was being elevated through it, until the instant at which the feeding apron was stopped; second, when the machine was running empty after a heavy load had been going through the rolls and the rolls were open to full capacity, the machine would frequently plug again when it was started up. In an attempt to answer the cause of these two conditions I have gone into some of the theoretical considerations of elevating silage along with the practical conditions as we found them.

The data given in Table III is taken from some of the tests conducted at the University of Minnesota. The first four columns in this table are data that were measured during our tests. The fifth column, that of the power required for elevating the silage, is calculated. This calculation is based on the rate of cutting, the size of flywheel and the speed at which the ensilage leaves the flywheel.

¹Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, November, 1927.

²Associate professor of agricultural engineering, University of Minnesota. Mem. A.S.A.E.



The ensilage cutting tests with electric motors conducted in 1927 at the University of Minnesota and other state institutions produced very significant results and have created widespread interest

The velocity with which the silage leaves the flywheel is given in Table IV.

We made some attempt to measure the velocity of discharge at the point of discharge, but after several trials we came to the conclusion that we were not far out of the way if we were to use the peripheral speed based upon a diameter two inches less than the diameter of the fan blades. This figure was used in determining the minimum amount of power that was necessary to bring the cut ensilage up to the discharge velocity. No friction losses are considered in this calculation.

The sixth column in Table III is calculated in a similar way for the air. We assumed approximately the same velocity for the air as that of the silage. The velocity of the air as determined from the velocity head measurements is given in Table IV. The eighth column in Table III is taken from actual measurements of the power used to run the machine when idle. The last column in Table III gives the maximum efficiency of elevation. These figures are based upon a 6½-in. pipe, 30 ft. long, using the minimum power requirement for elevating the silage as given in Column 7. The efficiency of elevation is determined by dividing the theoretical power required to elevate 10.5 tons per hour a height of 30 ft. as compared to the power given in Column 7. This of course is a minimum value of the power and therefore the efficiency is the maximum value.

In actual practice, when friction is taken into consideration the elevating efficiency would be somewhat less than the percentages given in Column 10. The amount of power remaining to use for other purposes, outside of running the machine idle and elevating the silage and the air that goes with it, represents the amount of power used up in cutting the ensilage and in air and silage friction in the blower. The air friction may be slightly increased over what it is for idling so the figure given as that of the power remaining may include some small amount used to overcome the friction of the air in the blower. There undoubtedly is also a small amount of power used to maintain the pressure in the blower pipe. It is impossible to figure how much power would be necessary for this, as it depends upon so many different things in connection with the shape of the blades, the shape of the housing and other conditions of the blower.

It will be noted in Table III that the first three tests as shown in the first three rows of figures are based upon a very similar rate of cutting. The difference in the three tests is but very little. The power requirements, however, differ considerably due to the difference in speed. It will be noted that most of the difference in the power requirement is that required for elevation. In fact, the second and third tests both show more power remaining after subtracting the power which is used for elevating and for running the machine idle, than we had remaining in the first test. It is also quite noticeable that at the lower speed a very much smaller amount of power is required for elevating the silage and the air than is required at the higher speed. Undoubtedly this is the point where most of the gain is made in running ensilage cutters at low speed. It will also be noted how the efficiency of elevation increases at the lower speed. We operated the ensilage cutter for a short time at a speed below 348 r.p.m., but I did not have the other records which are necessary for computing the figure given in these two tables for the low speed of 336 r.p.m. I am of the opinion that the ensilage cutters can be operated satisfactorily at speeds even below those recorded in this test.

In Table IV, it will be noted that the data contained in this table refer to the same series of tests as reported in Table III and are only a continuation of Table IV. The velocity of the silage as given in Column 2 is computed as the peripheral velocity at 2 in. less diameter than the diameter of the fan blades on the flywheel. This value is taken

TABLE I. Energy Consumption for Silo Filling

Farmer	Size of silo	Amount of silage	Tons of silage	Size of motor, hp.	Speed of cutter, r.p.m.	Total energy used, kw-hr.	Energy per ton, kw-hr.	Cost per ton at 3c per kw-hr., cents
W. A. Cady	12 x30 ft.	12 x25 ft.	54.15	10	570	60	1.107	3.32
B. I. Mellin	16 x47½ ft.	16 x42 ft.	169.31	15	650	304	1.790	5.37
F. A. Miller	14½ x32½ ft.	14½ x26½ ft.	84.54	10	570	120	1.420	4.26
Nelson Bros.	14 x40 ft.	14 x27 ft.	80.24	10	570	120	1.495	4.48

1. Silage volume measured and weight calculated according to figures compiled in K.S.A.C. Bulletin No. 222. Silage settled 25 to 30 days before being measured.
2. Cady's and Mellin's silage was free from water due to rains. Mellin's corn froze after about one-fourth of it was put in.
3. Miller's corn was cut a week early and laid in field during rain and was heavy, wet and full of grit.
4. Nelson's corn was wet from rains during filling.
5. The knives on the cutter at Nelson's were not changed until very dull and time was lost by the machine plugging up due to being slowed down by very dull knives, thus increasing the rate per ton.
6. Three knives and a ½-in. cut were used at all four farms.

because several tests, which we attempted to make in order to determine the velocity of the silage, showed that this was a fair value. A consideration of the volume of the ensilage that is thrown by each paddle would also bring us to the conclusion that the ensilage does not ordinarily occupy a width on the fan blade of more than 2 in. Under such a condition, it will be seen that the velocity at 1 in. from the outer edge of the fan blade would about represent the average velocity of the ensilage as it leaves the fly-wheel. The velocities of the air as determined from the velocity head measurements taken at the inner side of the housing at the opening of the blower are very comparable with the velocities of the silage. The accuracy of measurement of course is not very great and the values for the velocity of the air may vary considerably from those given in the table.

The static air pressure measurements that were taken at the bottom of the pipe together with the measurements of velocity head are not very satisfactory. The velocity head measurements are much more readily taken than are those of the static pressure. The static pressure measurements are so small that it will be necessary to use a differential gage to get them very accurately.

In order to determine whether much of the air or the ensilage was being blown through the delivery pipe it seemed of interest to me to determine the quantities given in the last three columns. The friction loss is calculated upon the air velocity as given in the third column and the pressure required at discharge is also calculated upon this same velocity. It will be noted that the total pressure required to overcome the friction loss and to give a sufficient static pressure to cause a discharge at the end of the pipe of the velocity as given in Column 3 is very many times larger than the air pressure as measured at the bottom of the pipe. In the first case, it is nine times as much and in the last case ten times as much. The average is somewhere between ten and eleven times as great a pressure as the actual pressure measured at the bottom of the pipe. This would indicate that the air is thrown out very much the same as the ensilage is, rather than being blown out.

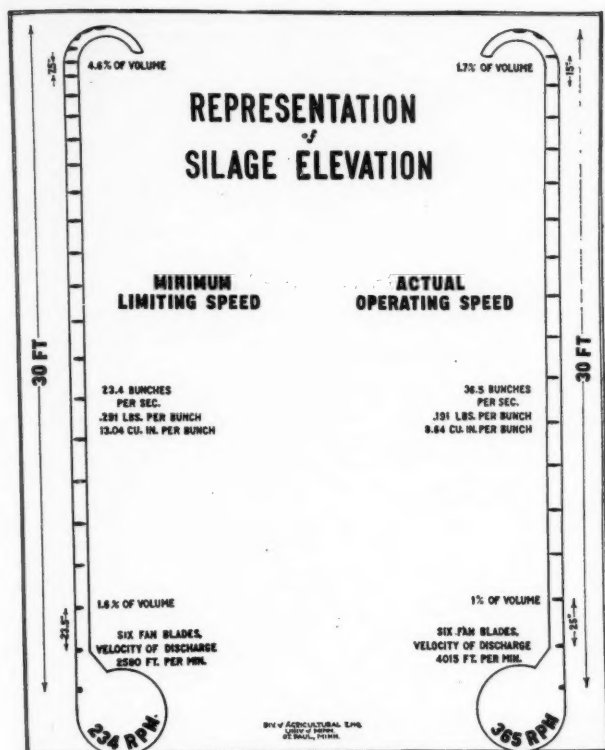
In making a further study of the reasons for the ensilage clogging in the pipe under the two conditions noted above I have tried to picture, theoretically at least, what happens to the ensilage and the air as it passes up through the delivery pipe. We have represented two conditions, the actual operating speed of 365 r.p.m., and the minimum limiting speed for 30-ft. elevation of 234 r.p.m. The velocity of discharge at the higher speed is 4,015 ft. per min. where the ensilage leaves the tip of the blade. The velocity of discharge in the limiting case is 2,580 ft. per min. This is just sufficient velocity for a free throw to lift a body 30 ft. in the air. Under the condition of the higher velocity, of 4,015 ft. per min., this is high enough velocity for a free throw to lift a body 70 ft. in the air. The velocity of discharge together with the speed in r.p.m. and the free throw height is given in Table V. With reference to this table it will be noted that very low velocities and very low speeds are required for the elevation to a height of 60 or 70 ft. if we could deal with a free throw. It is very evident that the air in the pipe or else the resistance of the silage in passing through the pipe has a very high retarding effect upon the elevating of the silage.

I have attempted to show diagrammatically what would

happen to the bunches of ensilage as they pass up through the pipe providing they kept distinct and separate from each other. While they undoubtedly do not remain as distinct as shown, yet it is a noticeable fact that they do retain somewhat their bunch identity as they pass through the pipe. We also know that these bunches go from one side of the pipe to the other, and we have attempted to show this diagrammatically in the figure. It will be noted in the figure for the limiting speed how the bunches of ensilage come together as they near the top of the pipe. It will also be noted that this is not so noticeable at the higher velocity of 365 r.p.m. While 365 r.p.m. is considered a low velocity, it will be seen that, under the average operating conditions of 600 and 700 r.p.m., the shots of ensilage as they pass up through the pipe would not come much closer together at the top than they are at the bottom. The fact that they do come much nearer together in the lower velocities is one of the things which undoubtedly causes some interference in elevation at real low speeds.

To bring out more clearly the difference in distance between bunches, the figures show that for the minimum limiting speed the shots or bunches are about 23½ in. apart as they leave the blower while at the top they would be about 7½ in. apart, if we consider only a free throw, while, on the other hand, at the higher speed of 365 r.p.m. the bunches would be 25 in. apart at the lower end of the pipe and they would still be 15 in. apart at the top of the pipe.

It has sometimes been stated that the small pipes do not have large enough capacity for elevating the ensilage at low speeds when cutting at a fairly high capacity. The fallacy of this is probably shown in the figures as given on the accompanying chart. When operating at a speed of 365 r.p.m. with six fan blades there will be 36½ bunches per second. These bunches when cutting at the rate of 8.16 tons per hour, which was the actual rate cut at this speed, each bunch would weigh 0.191 lb. and would occupy approximately 8.64 cu. in. At the lower end of the pipe the corn would occupy just one per cent of the volume and at the top of the pipe it would occupy 1.7 per cent of the volume. On the other hand, if we were to cut at the same rate at the lower speed of 234 r.p.m., there would be 23.4 bunches per second, each one weighing 0.291 lb. and occupying approximately 13.04 cu. in. per bunch. These bunches would occupy 1.6 per cent of the volume of the pipe at the bottom and 4.6 per cent of the volume of the pipe at the top under the conditions of a free throw. In either case it will be noted what a small percentage of the volume is actually occupied by the corn showing that the pipes certainly do have large enough capacity even in a 6½-in. size, when operating at fairly high rates of cutting with low velocity, but notice how this percentage increases at the top of the pipe at low speeds. It would certainly be interesting to know just what happens to the air in the pipe as the silage passes through. While the silage may change its speed from that at which it is going at the bottom of the pipe to what it will be at the top, yet we can conceive of no possibility whereby the air can do this. The air must have a uniform velocity throughout the pipe. If this velocity is equal to that of the silage at the top of the pipe, then the air will exert a very much retarding effect on the ensilage below this. On the other hand, if the air is moving at a velocity which is equal to that of the corn in the lower part of the pipe, then it would assist very materially in clearing the



This diagram shows theoretically what happens to ensilage and air as it passes up through the delivery pipe under two conditions—the minimum limiting speed for 30-ft. elevation of 234 r.p.m. and the actual operating speed of 365 r.p.m.

corn out of the top of the pipe. Actual operating conditions, however, do not show that the air is travelling with an average velocity equal to the higher velocity of the ensilage at the bottom of the pipe. On the other hand, if the air travels at a velocity which is that of the ensilage at or near the middle section of the pipe, then the air will assist somewhat in carrying the ensilage out of the top of the pipe but will retard the passage of the ensilage at the lower part of the pipe. This is probably the condition that is met in practice as the plugging of silage elevating pipe usually occurs near its base.

Since the results of our tests show very decidedly that a decrease in speed means a decrease in cost of operation as well as a decrease in the power requirement, and since this fact has also been shown by other investigations that have been carried out by F. W. Duffee at the University of Wisconsin and by other investigators, it appears that it is worth a good deal of study to find out what can be done to secure proper elevation at as low speed as possible. It may be that the use of a pipe of nonuniform cross-section, or of a pipe so arranged as to relieve the air pressure at the lower end of the pipe or some other such arrangement, might make it possible to elevate silage more efficiently at lower speeds. If some arrangement could be devised so that advantage could be taken of the air movement to help carry out the ensilage, this undoubtedly would increase the efficiency of elevation. At lower speeds we may find that it is possible to actually blow the ensilage through the pipe rather than to throw it through the pipe. This is only a

guess but the subject is certainly worthy of some serious study and investigation.

I have referred to the fact that our investigations have shown that lower operating speeds mean lower cost for the power used in cutting and also means that a small amount of power can be used to cut the ensilage at fairly high rates. The accompanying graph shows this very conclusively. At the higher speed of 725 r.p.m., 16 hp. was required to drive a 16-in. cutter, cutting approximately 10 tons of ensilage per hour. The cost of cutting at this high rate of speed was 1.4 kw-hr. per ton. Both the power required to run the cutter and the amount of energy required to cut each ton decreases in a very nearly direct ratio with the decrease in speed. In fact, the power requirement and the energy requirement decrease at a slightly greater rate than the decrease in speed as shown by the chart, so that at the lower speed of 348 r.p.m. it required but 4.75 hp. to cut the ensilage at the rate of 8.53 tons per hour and required only 0.548 kw-hr. per ton.

Part 2. Cutting Ensilage With Electric Motors

The first ensilage cutting with electric motors that was done in the experimental work at the University of Minnesota in 1924 was with a 15-hp. motor, using the larger sized (16-in.) ensilage cutters. The practice of using high speed on the cutters was tried out. When run at speeds of 750 to 800 r.p.m. the motor was overloaded to as high as 26 hp. The silo held about 170 tons of which 80 tons were cut with the motor, which required 192 kw-hr. of energy. This is an energy consumption of 2.4 kw-hr. per ton. The remainder, or 90 tons, was filled by use of a tractor at a cost of 9.2 cents per ton for kerosene and oil. With electricity at 3 cents per kw-hr., the energy cost was 7.2 cents per ton. At another farm 150 tons of ensilage were cut with the motor operating the ensilage cutter at about 700 r.p.m., using 300 kw-hr. of energy, or at the rate of 2 kw-hr. per ton. These tests showed that a motor was practicable when it had been declared to be impracticable. It also showed that high speed operation of the cutter was unnecessary and expensive.

During the ensilage cutting season the following year, we used a 10-hp. motor for most of the work, using the 15-hp. motor at the farm of B. I. Melin only. The cutters used were a 13-in. Gehl and a 16-in. Papec. These were run at about 570 and 650 r.p.m., respectively. The resulting saving in energy consumption by using the smaller motor, operating the cutter at a lower speed, is shown in Table I. Again the 15-hp. motor operating the cutter at the higher speed used nearly 179 kw-hr. per ton, while the 10-hp. motor driving the cutter at 570 r.p.m. operated at less than 1.5 kw-hr. per ton. At times the 10-hp. motor carried as much as 18 hp. when driving the Gehl cutter at 550 r.p.m.

These results and tests indicated that lower power motors could be used and that lower speeds of the cutter were desirable. During the season of 1927, a large number of tests on different farms were conducted with different makes of cutters and with different makes of motors varying in power from 5 to 15 hp. The results of these tests show clearly that very low energy consumption can be secured by using small power motors with low speed operation of the cutters. A summary of the results gives the average values shown in Table II.

TABLE II. Summary of Test Results

Size of motor, hp.	Rate of cutting, tons per hr.	Speed of cutter, r.p.m.	Power used, kw-hr.	Kw-hr. per ton
5	7.13	336-440	4.65	0.667
7½	7.55	410-443	5.81	0.862
10	10.39	440-580	10.17	0.978
15	9.56	570-725	13.18	1.405

TABLE III. Tests with 16-in. Ensilage Cutter—30-ft. Pipe

Speed, r.p.m.	Rate tons per hr.	Kw-hr. per ton	Power, hp.	Calculated minimum power for elevating—hp.			Power idling, hp.	Power remaining, hp.	Maximum Efficiency of elevation, 30 ft.—per cent
				Silage	Air	Total			
725	10.5	1.405	16.00	5.88	1.54	7.42	1.62	5.96	4.2
580	10.57	1.255	12.30	3.77	0.81	4.58	1.43	6.99	6.9
440	10.87	0.777	9.50	2.23	0.35	2.58	0.85	6.97	12.7
365	8.16	0.600	4.96	1.15	0.19	1.34	0.67	2.95	18.4
348	8.53	0.548	4.75	1.09	0.16	1.25	0.62	2.88	20.6

TABLE IV. Velocities and Air Pressures in 6½-in. Pipe, 30 ft. Long—16-in. Cutter

Speed, r.p.m.	Velocity of silage, ft. per min.	Velocity of air, ft. per min.	Velocity head*	Static air pressure* at inlet (measured)	Friction loss (calculated)	Pressure required at discharge* (calculated)	Total pressure*
725	7975	7944 ± 40	4.0	1.05	5.51	4.15	9.66
580	6380	6316 ± 40	2.55	0.60	3.54	2.65	6.19
440	4840	4885 ± 50	1.5	0.35	2.54	1.52	4.06
365	4015	3972 ± 60	1.0	0.20	1.40	1.05	2.45
348	3830	3770 ± 60	0.9	0.22	1.26	0.95	2.21

*Inches of water.

Some facts are clearly shown by the data from these tests. Operation of the machine at or near the capacity of the motor gives a low energy rate. With the 7½-hp. motor, one man would seldom feed it up to the capacity of the motor. The average rate of cutting with the 7½-hp. motor is but little more than for the 5-hp. motor, and the power required is only about 6¼ hp. In practically all tests, the feeding was done by one man. One man can feed at a higher rate than 7.55 tons per hour, but, if he is not urged to do so, ordinarily he will not do so with bundles weighing 20 lb. each, or less. There was another factor, however, which held down the capacity of the machine operating with the 7½-hp. motor. With the 15-in. cutter running at a speed of 440 r.p.m. the capacity, with one man throwing off and no one feeding, was limited to about 8 tons per hour with short corn. Our maximum capacity for a full load was 7.86 tons per hour. When we attempted a faster rate than this, the butts of the bundles would double over at the feed rolls, frequently stopping the feed. When this happened enough time was lost so as to cut down the rate of cutting to less than 7 tons per hour.

The entire ensilage cutting job at the farm where the 7½-hp. motor was used with the 15-in. cutter required a total elapsed time of 14.5 hr. During this time 92 loads, totalling 78.2 tons, were cut with an energy consumption of 66 kw-hr. This gives an average energy consumption of 0.844 kw-hr. per ton, which is very close to the average given above for the 7½-hp. motor tests. There were 1.3 hr. out of the 14.5 hr. wasted while waiting for corn. The machine was stopped during about two-thirds of this time and allowed to run idle the remaining time. On a basis of 14.2 hr. running time which includes the time for changing wagons, removing plugs in pipe, etc., the average rate of cutting was 5.92 tons per hour. During the time while they operated the machine without any interference because of our tests, they put in 75 loads and had trouble but four times with a plugged pipe. The cutting was handled with four men and four teams. This

TABLE V. Free Throw Height at Different Speeds

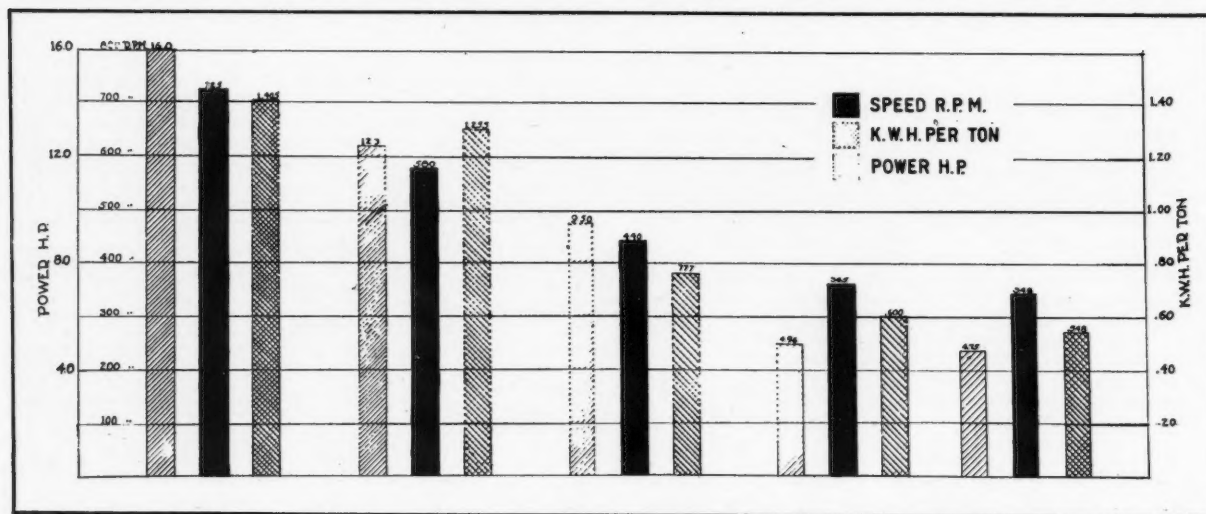
Speed	Velocity	Height
243	2580	30
276	3034	40
299	3379	50
338	3715	60
365	4016	70
378	4166	75

job required only 0.75 man-hours per ton of ensilage cut. The cost of energy at 3 cents per kw-hr. was only 2.5 cents per ton. These costs are quite low as compared to 1.83 man-hours per ton and a full cost of 7 cents per ton as given in the Wisconsin Bulletin No. 386 for 282 farms in Wisconsin.

The operation with a 5-hp. motor shows that it was not ordinarily overloaded. The only tests that showed an overload were those when running the 16-in. cutter at 400 r.p.m., and when operating the same cutter at 365 r.p.m. with dull knives. The overload under these conditions was not serious (16 per cent) even when cutting the ensilage at a rate of 8.6 tons per hour. When operating the 13-in. cutter at a low speed of 348 r.p.m., the 5-hp. motor cut 7.83 tons per hour at an energy consumption of 0.548 kw-hr. per ton and required about 4.8 hp.

The tests conducted with the 10-hp. motor indicate that a capacity, equal to what one man can feed, can be secured with the 16-in. cutter driven at a speed of about 440 r.p.m. The average man will not keep the motor loaded. With heavy bundles of large corn one of the best men working very hard fed at the rate of 10.87 tons per hour, which required 8.53 kw. power input (9.5 hp.). A man would not want to work at this rate for even one hour. With two men feeding, and at the same speed, the rate was 12.52 tons per hour and required about 10.3 hp. Working under this condition of full load on the motor and at a minimum speed for this capacity, the energy consumption was only 0.745 kw-hr. per ton, which is less than the average for the 7½-hp. motor on all runs. This capacity cannot ordinarily be secured at this speed. We secured it by using a man at the feed table and with large corn. At a higher speed of 580 r.p.m. two men fed at the rate of 12.5 tons per hour without having a man at the feed table. At this speed the power required was 13.6 kw. with the motor overloaded nearly 50 per cent, and the energy required jumped to 109 kw-hr. per ton, or an increase of 46 per cent. With one man feeding, using large bundles and working at higher than average rates the rate of cutting was about 9 tons per hour to utilize the full power of the motor.

The two tests with the 15-hp. motor were given just to show what the power and energy requirements are at the higher speed. The rate of cutting is not any higher than



This graph, representing the relation of power and energy requirements to the speed of the ensilage cutter based on the results of the Minnesota tests, shows that lower operating speeds mean lower cost for the power used in cutting and also means that a small amount of power can be used to cut ensilage at fairly high rates

what we secured in certain cases with the 7½-hp. motor, as this depended upon the men. The results do show, however, that it is unprofitable to run the cutter at high speeds, and require a large motor to do it with when using only one or two men for feeding. In general the results show that it is not economical to use two men for feeding, as the increase in cutting rate is only about 50 per cent for two men over what it is for one man.

One capacity test was quite interesting. The sixth test with a 7½-hp. Wagner motor, driving the 13-in. cutter at a speed of 425 r.p.m., was conducted by having two men throw corn onto the feeding apron and one man at the feeding table. Under this condition the rate of cutting was 10.56 tons per hour, and required a power of only 7.06 kw. (7.6 hp.) and the energy requirement dropped to 0.667 kw-hr. per ton. This shows how important it is to operate the cutter at a low speed, and yet to load the motor to its capacity. The floating feed roll was held tight against the top of the guide for intervals of more than a minute at a time, and was nearly at the top the whole time. This indicates that more feed capacity is required to operate these machines at low speed with motors of 7½-hp. or larger.

Sharp knives are very important. The saving with sharp knives is more than 35 per cent in the energy used, and a saving of 30 per cent in time due to increased capacity, as shown in the following tabulation:

Knife Condition	Rate of cutting	Kw-hr. per ton
Dull (5-hp. motor)	5.90 tons	0.962
Sharp (5-hp. motor)	7.52 tons	0.609
Dull (7½-hp. motor)	6.10 tons	1.220
Sharp (7½-hp. motor)	8.24 tons	0.810

The success of using a 5-hp. motor for filling the silo depends upon three things: (1) The speed of the cutter, (2) condition of the knives, and (3) voltage regulation at

the motor. If the ensilage cutter is driven at a speed of 400 r.p.m. or less with sharp knives properly adjusted with not more than ¼-in. clearance between the fan blades and the housing, and with voltage regulation so that the voltage at the motor does not drop below 200 volts on overload, the 5-hp. motor will handle the ensilage cutting satisfactorily. Good voltage regulation can only be secured by having the transformer within 100 ft. of the motor, or else using No. 2 or heavier wire for the secondaries of the transformer.

Our tests with secondaries of 400 ft. of No. 6 copper wire from transformer to motor, and with 418 ft. of the same size wire at another farm, show that a 5-hp. motor cannot pull its full overload so as to carry through the heavy slugs. The voltage in such cases drops to as low as 153 volts, and the motor cannot get more than about 6.5 kw., or 30 per cent overload. On the first one of these farms, 345 ft. of the secondary (transformer to meter) was changed from a No. 6 to a No. 2 wire, and when a 7½-hp. motor was used, the voltage still dropped to 153 volts (normal voltage at no load being 222 volts) with 10.4 kw. input, or about 30 per cent overload at this voltage. The transformer was then changed to one with variable taps, and the no-load voltage stepped up to 239 volts. Starting with this voltage the motor would carry an overload up to 10.6 kw., or about 50 per cent overload, and the voltage would drop to only 206. Under this condition, the motor would not slow down on the overload and the cutter pipe would not plug. Our tests indicate that the 5-hp. motors should not be used with secondaries longer than 200 ft. of No. 6 wire and unless the no-load voltage can be stepped up to about 235 volts. The 7½-hp. motors should not be used with more than 150 ft. of No. 6 wire for secondaries, unless the voltage is high. The use of larger wire is not economical for runs larger than about 300 ft. It is usually better to move the transformer closer to the job. A 3-kva. transformer has been very satisfactory for the 5-hp. motors and a 5-kva. for the 7½-hp. motors.

Laboratory Tests of Orchard Heaters¹

By A. H. Hoffman²

A STUDY was made of the performance characteristics of heaters designed to prevent frost damage to citrus and other fruits. Methods were devised for making quantitative measurements of these characteristics in the individual

¹Abstract of Bulletin No. 442 of the California Agricultural Experiment Station. Copies may be obtained on request to the author at University Farm, Davis, Calif.

²Research specialist in agricultural engineering, University of California. Mem. A.S.A.E.

heaters where the methods commonly employed by mechanical engineers were found inapplicable or inadequate. Answers to the following questions were sought:

1. What are the characteristic burning or fuel consumption rates of the different heaters?
2. How efficiently do they convert fuel into heat?
3. What per cent of the heat is lost by radiation?
4. How fast do the hot gases rise from the stacks of the heaters?

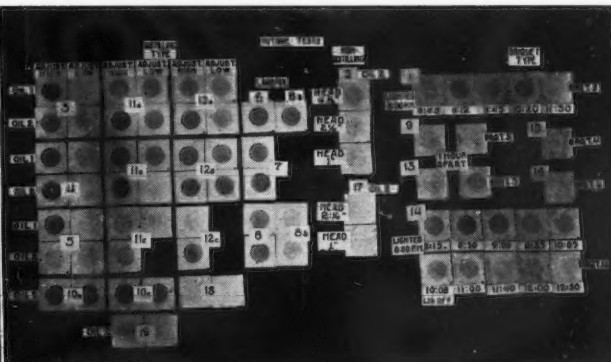


Fig. 1. (Left) The heaters tested were (1) Pomona, (2) Kittle, (3) Scheu Jumbo Cone Louvre, (4) Scheu Baby Cone Louvre, (5) Scheu Double Stack, (6) Bolton, (6s) Bolton (with spider), (7) Troutman, (8) Canco, (8s) Canco (with spider), (9) Diamond, (10) Dunn, (10C) Dunn (with 30-in. stack; not shown), (11A) Citrus, 9-gal. low stack, (11B) Citrus, 9-gal. medium stack, (11C) Citrus, 9-gal. high stack, (12A) Citrus, 6-gal. low stack, (12B) Citrus, 6-gal. medium stack, (12C) Citrus, 6-gal. high stack, (13) Karr, (14) Jessen (large), (15) Jessen (medium), (16) Jessen (small), (17) Low Delivery, (18) Baby Double Stack, (19) Citrus Gas Flame.
Fig. 2. (Right) Smoke records, out-of-doors tests. Equal volumes of gases at the same rate were drawn through all these felts. The darker the circles the more smoky the heater. Note (right) how two briquet heaters varied in smokiness as burning proceeded. (The card of heater No. 4 appears slightly below its proper place in the photograph.)

5. What temperatures are attained by the gases and by the heater surfaces?

6. How much smoke is produced by each heater, and how may a visible record of the smokiness be obtained?

7. What characteristics are necessary in a satisfactory fuel for orchard heating and how may they be determined?

Nineteen heaters, described and shown, were under study. Of these six were designed to burn solid (briquet) fuel and the rest low grades of petroleum distillates.

It was found that the briquet type heaters burned hourly from 1 to 4.6 lb. of fuel and the oil burners from 1.2 to 15 lb., liberating respectively from 17,000 to 75,000 and from 24,000 to 300,000 B.t.u. per hr. Since in the discharged products of combustion no measurable quantity of carbon monoxide and less than 0.1 per cent (of the weight of fuel used) of soot and smoke could be found, it was concluded that the fuel-to-heat conversion efficiency of all the heaters tested was above 99.9 per cent.

The energy above the horizontal plane (much of which would be lost) ranged from 1.1 to 4.5 per cent (of the heat content of the fuel used) for the briquet heaters and from 1.1 to 5.5 per cent for the oil burners. Simple baffles were found effectively to diminish radiation losses.

The upward velocities of the emergent gases ranged from less than 2.5 to 5 ft. per sec. for the briquet type and from the same low limit to about 14 ft. per sec. for oil type heaters.

Temperatures ranged from about 300 to 1400 deg. F. for the emergent gases and from nearly as low as air temperature to above 1000 deg. for the heater surfaces.

The weight of smoke and soot emitted ranged from practically nothing in several heaters when adjusted for low-burning rates up to about 0.04 lb. per 1000 cu. ft. of effluent gases in open lard pail type and in several stack type heaters when the latter were adjusted to very high rates of burning. The design of the heater seemed to have greater effect on smoke production than the kind or quality of fuel used. Visible smoke records were obtained by which comparisons could be made even when the weights of smoke were too minute for measurement.

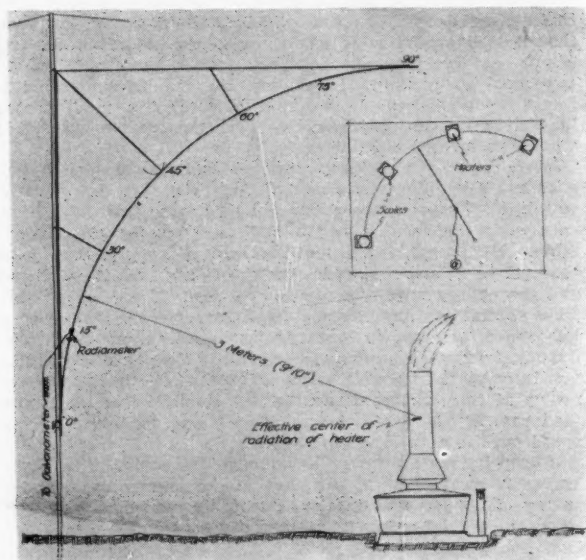


Fig. 3. Apparatus for measuring radiation from orchard heaters. Four heaters placed on scales set in an arc of a circle were tested in succession by swinging the radiometer from one to another. Readings were taken at seven positions from 0° angle (horizontal) up to 90° angle (vertical). The radiometer was connected electrically to a sensitive galvanometer in the instrument shelter.

Low sulphur content and little or no tendency to produce asphaltic and hard carbonaceous residues when burning were found to be desirable in orchard heater fuels. A simple test was devised to determine tendency in orchard heater oils to produce residues. A modified form of the test was made to enable the heater user to make a satisfactory qualitative determination.

Hay Hoists Prove Practical in Washington

By Harry L. Garver¹

THE hay hoist does for the farmer just what the crane does for the manufacturer of heavy machinery. It lifts the heavy loads for him. The power-driven hay hoist as found in Washington usually consists of a Loudon or similar hoist and an electric motor. Power is transmitted from the motor to the hoist by belt. A motor of from 2 to 5 hp. may be used, depending upon the size of fork or sling used and the weight of material hoisted. Several of these hoists are being used successfully in the state. A description of some of them will probably give the best idea of what is meant by an electric hay hoist.

The first hoist studied was a Loudon belonging to Frank Schneider, at Auburn. The hoist and driving motor are located inside of the barn while the wagons from which the hay is hoisted are outside. A 3-hp. Century electric motor is belted to the hoist.

It required 0.486 kw. to operate the hoist when idling, or less than half a horsepower, taking into consideration the efficiency of the electric motor at low load. The average power requirement when hoisting is 2.214 kw., the highest requirement noted being only about 2.6 kw. which, at an estimated efficiency of 75 per cent, is well under the rating of the motor.

The time necessary to unload a wagon could not readily be checked as the outfit is new and was not fully adjusted, except the steel rope which was old and was giving considerable trouble. An estimate, however, may be made from data taken when hoisting. The time required to take off a forkful ranged from 30 to 45 sec. (This is the time which

elapsed from the moment the cable tightened until the forkful was tripped.)

No power was recorded for the haul back as the rope and block for this feature had not been installed. The fork was drawn back by hand. The crew for putting up hay on this job consisted of eight or nine men. One man with a team hauled the loaded wagons to the barn and returned the empty ones to the field. Five wagons were used. One man handled the fork and another the hoist while two or three men did the mowing.

Two horses, a Fordson tractor, and 3-hp. electric motor were used for power. An average of four wagons per hour were handled. The length of haul through the field and to the barn averaged about one-half mile. The weight of hay to the load was estimated at one ton. The wagons were unloaded with four forkfuls.

With the foregoing figures as a basis for calculation, the cost of power for a day's run (10 hr.) would be as follows:

1 $\frac{3}{4}$ hr. actual hoisting (2.214 kw.)—3.69 kw-hr.
8 $\frac{1}{4}$ hr. of idling (0.486 kw.)—4.05 kw-hr.

Total 7.74 kw-hr.

At 3 cents per kilowatt-hour the cost of power for the day is approximately 23 $\frac{1}{4}$ cents. The cost of the hoist and ropes was \$137.

The second hoist studied was that belonging to Joe Dettling near Stanwood. It is the same as the first one, but the arrangement for transmitting power from the motor to the hoist is quite different. Mr. Dettling uses a 5-hp. Westinghouse single-phase motor. This same motor also drives his milking machine. The belt was taken off the milking

¹Rural electrification investigator, State College of Washington, Mem. A.S.A.E.

machine pulley, and placed on the drive pulley on a line-shaft. Another belt was used from the lineshaft to the hoist. The pulley ratios as used resulted in a sixteen per cent increase in speed over that of Mr. Schneider's hoist.

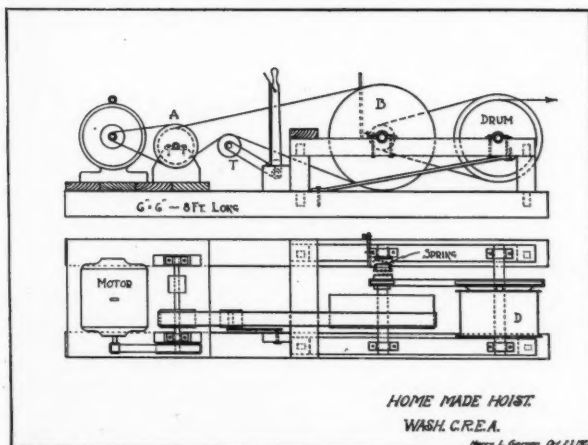
Two single harpoon forks instead of one double harpoon were used. Two lifts were required per load. The loads would average about one ton each. Twenty to thirty tons per day were hauled. There were three reasons for this comparatively low figure:

1. Small crew. The wagons were loaded by hand and the men who loaded the wagons came in to the barn to help unload.
2. Long haul. The distance from the barn to the nearest entrance to the hay field was about one-half mile.
3. Short day. The hoisting motor, as well as part of the crew, was used for milking both morning and evening, thus allowing a haying day of only seven or eight hours.

A graphic wattmeter was used to measure the power requirements and time of hoisting as well as to furnish a means of studying the operating characteristics of this type of farm machine. The average time required for unloading each pair of wagons was about 23 min. while the average time for loading the two wagons in the field was about 25 min. The average maximum power requirement was about $3\frac{1}{4}$ kw., while the average minimum (idling) was nearly $1\frac{1}{2}$ kw. The maximum load on the motor occupied only about 21 per cent of its running time, and the running time was only about 50 per cent of the entire time for the haying day. This means that the maximum load was on the motor only 10½ per cent of the time, the time between maximum peaks being approximately 5, 10, 5 and 30 min. Actual duration of the maximum load was only about twenty seconds. This would give a small motor with short-time overload capacity sufficient time in which to cool down. The forks were drawn back by hand which, of course, decreased the total energy consumption some, but it probably increased the time required for unloading.

Rapid chart speeds were used in an effort to analyze the character of the maximum load. They indicated that little, if any, more power was required for tearing the forkful loose from the remaining part of the load than for hoisting after it was torn loose. One chart reveals the fact that the hardest pull came after the two ends of the load were torn loose and rolled up together. The second lift cleaned the hay rack. It was a heavier lift than the first and while it looks as though a hard pull were necessary to start it the fact remains that there was no tearing loose. The rack did not have a flat bottom, but it certainly could not have caused any wedging.

Another hoist studied was one used by H. W. Carolus near Hartline. I was unable to learn either the name or address of the manufacturer of this hoist. It has proven satisfactory through twelve years of successful operation.



Drawing of the homemade hay hoist used on the farm of F. S. Malben, near Burlington, Washington

A $7\frac{1}{2}$ -hp. General Electric three-phase portable motor was belted to it. This motor is also used for grinding feed, cleaning and treating seed wheat, and for driving the pump when the wind is not strong enough to run the windmill. Mr. Carolus uses a chaff gatherer on his combined harvester, and it was this chaff that was being hauled into the barn and unloaded with the hoist when I was there. Slings were used. One man was doing the job. He filled the rack with loose wheat chaff (400 or 500 lb.), took it to the barn and unloaded it. The motor ran only long enough to do the actual hoisting and return the slings. The hoist was run so fast that in less than a minute from the time the motor was started the chaff was in the loft and the slings returned. It took approximately one kilowatt-hour to unload 22 such loads of chaff.

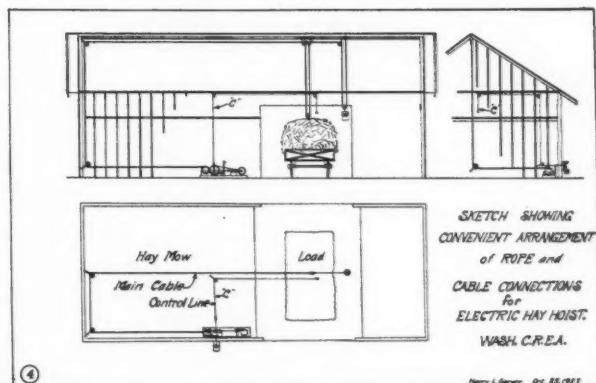
Another interesting hoist investigated belonged to F. S. Malben near Burlington. No operating data were taken on this hoist. The most interesting thing about it is its construction and the length of time it has been in service.

This is a homemade outfit, with old binder parts playing an important role in its make up. (See accompanying drawing.) A 2-hp. single-phase Westinghouse motor furnishes the power. Power is transmitted from the motor to a jack shaft by means of a silent chain, the ratio of speeds being five to one. The motor speed is 1750 r.p.m. The jack shaft has two pulleys besides the chain gear. A belt from one of these pulleys drives a second shaft on which the clutch is located. The ratio of speeds in this case is three to one. (The other pulley on the first jack shaft is used for running a feed cutter, grindstone, etc.) A tightener for this belt is operated by a lever from an old binder. The pulley on the second shaft is the drivewheel of the binder with the cleats removed. From this shaft to the drum, power is transmitted by the binder sprockets and chain, the only difference being that the small sprocket does the driving. The large sprocket holds the ring to which is anchored one end of the drum.

The clutch for this outfit consists of the standard ratchet binder clutch. A weight attached to a window cord holds the clutch open while another rope extending to the wagon permits the operator to overcome the pull of the sash weight, and to pull the hoist into gear from the load. No brake has ever been used on this outfit but Mr. Malben says that the machine would be greatly improved by the addition of one.

The drum is 17 in. in diameter and 12 in. long. The ratio of sprocket sizes is 10 to 34. This combination of pulleys and sprockets results in a drum speed of about 34 r.p.m., or a rope speed of 152 ft. per min., neglecting belt slippage. A ton of hay is removed from the wagon in five or six lifts. The rope, of course, is double from the load to the carrier. The direction of rotation of these shafts and drums, obviously, will depend upon which side the clutch lever is placed and the design of the ratchets. The arrangement of the tightener will be governed by the direction of rotation.

No arrangement for returning the fork by electric power is provided on this hoist. The fork is returned by means



Drawing showing a convenient cable layout for an electric-driven hay hoist. The hoist is put in gear from the load by rope, C. A spring helps to put it in gear and also to hold it there. A weight pulls the clutch out of mesh when the operator releases the rope

of a counter balance which works through a block and pulls parallel with the track. The counter balance is attached to the carrier and has nothing to do with the raising or lowering of the fork.

This outfit has been in service since 1907. It was driven by a gas engine until electricity became available in 1915, at which time the engine was replaced by the present electric motor. The cost of the hoist was small except for labor. There have been practically no repairs.

From my studies of hay hoists it would appear that there are no serious problems to be solved. The initial costs of the hoist may seem large and probably would be where only a small amount of hay is handled. Very frequently the hoist can be used for other purposes, such as lifting machinery, sacks of grain or feed, etc. The motor also may be used for many other jobs around the farm, thus absorbing its original cost and other fixed charges, such, for example, as connected load charge by the power company. The actual cost of power per day for operating the hoist is practically negligible.

Where the design of the hoist permits of control from the wagon as is done in the case of Mr. Maiben's, the operating cost becomes a matter of only a few cents per day.

A comparison of costs of operating the electric hoist and of the horse-drawn outfit is of interest. From thirty to forty tons of unbaled hay were hauled to the state college barns per day during the haying season and unloaded. The cost of the team for lifting the hay was set at \$2.56 for eight hours. The boy who drove the team received \$2.50. This made a total cost of \$5.06 per day. Assuming the boy's wages at Mr. Dettling's place and the state college to be the same, a comparison of operating costs between that of the electric hoist and the horse-drawn outfit becomes the difference between the cost of the team (\$2.56) and the cost of the electric energy (\$.25). From this it is seen that the former is \$2.31 greater than the latter. Compared with Mr. Maiben's hoist where the man on the wagon does his own operating the cost of power only is balanced against the \$5.06, making a difference of \$4.81 per day in favor of the electric hoist.

The Status of Farm Fire Prevention*

By I. D. Goss¹

IN THE present stage of farm fire prevention work the most important things are to establish a keen appreciation of the enormity of farm fire losses and to combat any false optimism which, however well-meaning, seeks to discount the seriousness of the matter.

The farm fire prevention movement is only two years old, having begun with a conference in Chicago between the farm insurance associations and the farm editors and publishers associations, followed by the appearance of a delegation headed by Prof. G. J. Christie, of Purdue University, at the annual meeting of the National Fire Waste Council at Washington, out of which grew the Agricultural Committee. The national Fire Prevention Association of Boston also organized a farm committee, and these two committees have been active ever since, largely, thus far, in determining quantitatively the extent and character of the problem.

Even with access to all known sources of dependable statistics, and with expert judgment in arriving at estimates this has been a rather difficult task. This, incidentally, emphasizes the improbability of dependable data being secured in any less laborious fashion. Taking the year 1924, which was an average year, and for which figures are fairly well available, the estimates begin with farm losses paid by stock companies totaling \$37,000,000. There are nearly 2500 farm mutual insurance companies in the United States, and of them 685 are members of the National Association of Mutual Fire Insurance Companies, and this group of 685 reports losses of \$33,000,000 which is estimated to be 40 per cent of the losses of all the mutuals, leaving \$49,000,000 as the estimate for the other mutuals. Owing to the policy of mutual companies to insure for substantially less than value the loss above insurance is set at 30 per cent, making another \$25,000,000. Similarly there is an item of \$10,000,000 for property not insured, \$5,000,000 for farm property in thickly settled communities and not segregated by agencies from the city property forming the bulk of their business, and a final item of \$10,000,000 including rural property not classified as farm property such as farmers automobiles, country schools, churches, stores, lodge halls, etc.

This runs up to a total of \$169,000,000, of which \$19,000,000 is stricken off as a margin of safety, bringing the estimate of farm and fire losses annually down to the round figure of \$150,000,000. Another estimate, based on government reports of farm building values, plus those of livestock, poultry and

dairy products, with deduction to allow for such products not on hand the entire year, plus an estimated \$12,000,000 for all farm operating equipment and personal property, insured at an estimated average annual rate of 70 cents per hundred, a low figure, gives a total premium of \$266,000,000. Applying the actual loss ratio on farm property which has been in excess of 65 per cent of the premium gives a total loss of \$172,000,000, which differs from the other estimates by only \$3,000,000. It is believed, therefore, that although the total loss is a matter largely of estimate, it is established with sufficient accuracy to define the magnitude of the problem.

Looking at it from another angle, this fire loss consumes one-eighth of the total net farm income, and this at a time when the farmer does not have one-eighth of his income to spare. The attitude of the insurance companies is shown by the fact that out of 200 stock companies less than ten made any pretense of writing a volume of farm business, while a large list of substantial companies have abandoned the field. Of those continuing to write farm business, it has cost them on the average \$1.08 for every dollar of premium.

Visualizing the matter still further the farmer's contribution to the national ash heap is sufficient to buy homes for the population of a city of 240,000 people, or build a solid row of barns 750 mi. long, while on a basis of half the losses being in the form of buildings their replacement consumes 7,500 acres of forest every year.

Having taken the measure of the problem, the committees on farm fire prevention believe that publicity and education are the most effective measures next to be taken, to awaken widespread public consciousness of the fire danger and train it in methods of reducing hazard. Other efforts include the beginning by the Bureau of Chemistry of the Department of Agriculture an investigation of spontaneous combustion in farm products, particularly hay; studies covering the organization and operation of rural fire department; investigation of location and construction of farm buildings in relation to fire losses. The major undertaking for this year is the preparation of an authoritative and comprehensive textbook which will cover the whole scope of farm fire hazards, prevention and protection, this to be a correlation of the best that is known and the best that can be developed during the year into practical and useful form not only for the use of schools, which are showing much interest, but as a reference book for farm leaders everywhere.

*Abstract of a paper presented at the meeting of the Structures Division of the American Society of Agricultural Engineers, at Chicago, December, 1927.

¹Chairman, Agricultural Committee, National Fire Waste Council.

Progress in Earth Wall Constuction¹

By J. D. Long²

THE first year's activity of the Committee on Earth Wall Construction of the American Society of Agricultural Engineers had for its purposes mainly the determination of (1) the geographical extent of the use of soil as a structural material, (2) the justification of this form of construction, and (3) the factors pertaining to the successful use of earth as a building material.

Widespread Use. From the personal observations of committee members, correspondence, and a perusal of the literature on the subject, it is apparent that building with earth is a practice known in most foreign countries and popular in some of them. For instance, it has been stated by a native engineer that approximately 95 per cent of the total construction in Mexico is of adobe brick. Geographic boundaries and climatic extremes apparently do not limit the use of the material, since successful examples have been reported in South Africa and Russia, in Peru and England, in New Zealand and Denmark. It is used in areas where 100 in. is the annual rainfall and in others where winter temperatures drop to 35 deg. below zero. The practice is so widespread, in fact, that one world traveler and agricultural student has stated as his belief that three-fourths of the earth's human population live in earth-walled structures.

In the United States there are widely scattered examples of earth-walled structures dotting the country from the Atlantic to the Pacific. They appear in Washington, D. C., South Carolina, Georgia, Virginia, West Virginia, Ohio, Illinois, Michigan, North Dakota, South Dakota, Missouri, Kansas and Arkansas, some of them being more than a century old. In some areas in Texas, Arizona, New Mexico, and California such structures constitute a very considerable amount of all building activity, and in Nevada, Utah, and Colorado they are no novelty. In Kansas, Nebraska and the Dakotas the sod house, which is one method of earth construction, acceptably served the pioneers of those regions and in some instances has been modernized and is still in use.

Various forms of earth-wall construction have been used in employee housing projects undertaken by large industrial concerns, for structures on urban and suburban development projects, and for all manner of rural structures. Sun-dried or adobe brick have been successfully used for most of the structures on the agricultural experiment stations of the U. S. Department of Agriculture at Shafter and Torrey Pines, Calif., and the state agricultural substation at Cheyenne Wells, Colo., has used both the cob and adobe brick methods for its structures.

Investigators at eleven educational institutions or agricul-

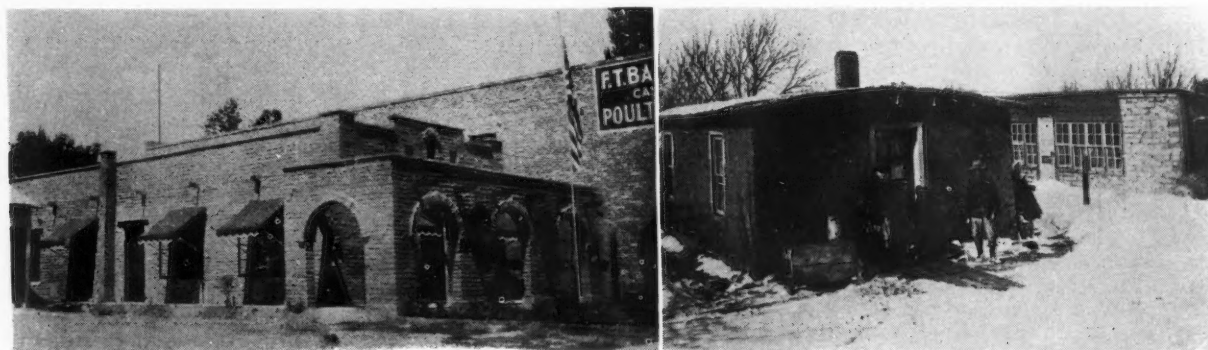
tural experiment stations have erected structures or conducted some experimental work with the material within the past seven years. These institutions are the Georgia Agricultural Experiment Station, University of Michigan, University of Minnesota, University of North Dakota, North Dakota Agricultural College, David Ranken, Jr., School of Mechanical Trades at St. Louis, Kansas State Agricultural College, Colorado State Agricultural College, New Mexico College of Agriculture and Mechanic Arts, University of Arizona, and University of California. One of these has reported that the results were successful, but that there is no future for such construction; another that earth building can not compete with the already available materials in that region; and a third, that the soils available were not suitable to the rammed-earth method first attempted, but that they have appeared satisfactory for sun-dried brick. The others, aside from difficulties common to first efforts, appear to consider their work successful and the method promising for certain classes of structures. Bulletins and circulars describing and recommending such construction for certain structures are available from two institutions.

Compared to the total volume of building activity in the United States, the amount of earth-wall construction is insignificant. For certain small rural structures, however, it promises advantages over methods now in common use.

Advantages. The justification for this form of construction appears to center on two main points: First, the economic advantage resulting to a builder who is able to utilize his own labor or gainfully employ his farm workmen on much of the building when they are not otherwise employed, and so save the capital expenditure for commercial materials and skilled labor on parts of his structure; and second, the securing of more comfortable structures.

C. V. Maddux, labor commissioner of the Great Western Sugar Company, Denver, Colo., states in a letter to J. W. Sjogren, Colorado Agricultural Experiment Station, " our experience in the construction of small houses by use of adobe material leads us to state that the original cost, including both labor and material, is about the same as that for building a frame structure, but the adobe structure is more comfortable, both during the summer and during the winter, and if properly built will last longer than frame and cost less to maintain. Furthermore, a larger part of the total construction cost of an adobe house is composed of labor than in the case of the frame structure the owner of the building often arranges to perform the labor required at a time when he is not otherwise employed, which obviously is to his economic advantage.

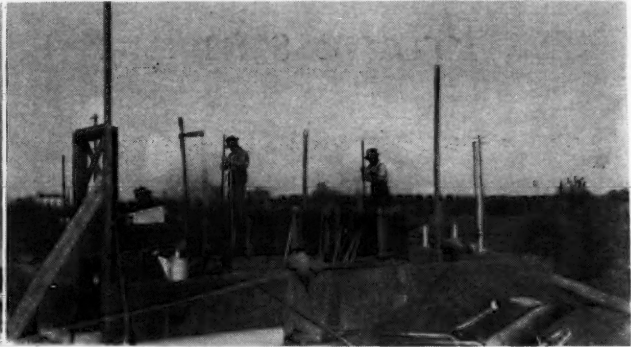
"The cost of the lumber, cement, etc., required for building a two-room adobe house 16 by 30 ft. is about \$150 when



(Left) The Farm Bureau office building at Visalia, Calif., erected of sun-dried brick in 1926 by the volunteer labor of the Farm Bureau members. (Right) A small laborer's house built by the cob method on the Plains substation of the Colorado Agricultural Experiment Station at Cheyenne Wells. The poultry house at the rear is of sun-dried brick

¹Abstract of the 1927 report of the Committee on Earth Wall Construction of the American Society of Agricultural Engineers.

²Junior agricultural engineer, University of California. Chairman, American Society of Agricultural Engineers Committee on Earth Wall Construction. Assoc. Mem. A.S.A.E.



(Left) A Colorado barn of sun-dried brick which has been stuccoed along the front wall. (Right) An experimental rammed earth poultry house under construction at University of California

the house is made with a flat roof, and about \$50 more when it is made with a gable roof."

J. W. Adams, superintendent of the Plains Substation, Cheyenne Wells, Colo., wrote in June, 1926: "..... as to the suitability of adobe as a building material in this region, will say that for combining cheapness and comfort adobe cannot be surpassed. As for durability, the buildings erected here in 1910 and described in Bulletin 174 are still in good condition, although they have not yet been stuccoed or in any way protected from the elements. I think they have weathered away about one and one-half inches in the 16 years. It is planned to stucco them this summer. The annual precipitation here is around 16 inches. This comes largely in heavy showers, though we frequently have drizzly weather for a week at a time."

R. C. Miller, of the North Dakota Agricultural College, reports that one of the factors prompting the investigation of this form of construction at that institution is that the only native materials available to the farmers in most parts of the state are rock and soil. He also quotes a farmer of that state who built a house and barn in 1924-25, using 14-in. rammed earth walls, as stating that the structures are satisfactory and comfortable, even in temperatures 35 deg. below zero.

The possibilities of using volunteer labor successfully in reducing costs influenced the Farm Bureau of Tulare County, Calif., to erect an adobe brick office structure for its own use in Visalia in 1926. The structure is 27 by 70 ft. inside, and one story high, with walls 12 in. thick. One paid foreman was on the job during most of the construction, but the two farm advisors were in charge of the work. More than one hundred members of the Farm Bureau worked on the building at various times, totalling about 2,000 hr. of volunteer labor. None of the men had had any previous experience with this form of construction. The cost of the completed building, including \$2167.11 for commercial materials, skilled labor, and lunches for the volunteer labor, and including an item for the value of the volunteer labor, at 40 cents per hour, was about \$2,950, or at the rate of \$1.65 per square foot of enclosed area.

Among the most important factors pertaining to the successful use of soil as a structural material are the procedure, or the choice of method, and the characteristics of the soil. Intelligent workmanship, attention to structural design and weather-proofing are all factors to be considered, however.

Methods. Under our modern conditions there are five methods which appear practical for incorporating soil into a wall. The sun-dried or adobe brick method has been most widely used, both in this country and in foreign countries. It consists of molding a stiff mud, to which straw has usually been added, into regular-shaped blocks which are then thoroughly dried in the sun and laid up in the wall much as ordinary burned brick is used, and using mud, lime or cement mortar.

The rammed earth or pise' de terre method consists of tamping damp soil between forms to form a monolithic wall.

Unit form panels are customary, the wall being erected in courses.

The poured adobe or mud concrete method consists of pouring a well-mixed mud between forms, much as concrete is poured. Pouring continuous courses six to twelve inches deep appears to be the most successful practice.

The cob method which obtains its name from England consists of piling a stiff mud, to which straw has been added, along a wall in courses. Forms are not used, the depth of the courses being regulated by the stiffness of the mud. Before the layer is dry the sides are trimmed plumb with a hay knife.

The timber framework with earth filler walls method consists of erecting a timber skeleton frame and filling between the wood bearing members with soil. In some instances sun-dried brick have been used for the filler material, and in others forms have been nailed or clamped to the framework and mud poured in place or damp soil tamped in place. This method, variously termed "terra armada," "cajon," "bindings-work," or "timber framework," is the only one where the earth wall itself does not support the roof load.

The choice between methods apparently depends upon the soil to be used, the climate, the size of the working crew, and the preference of the builder. Coarse-grained soils tamp more readily and so appear to be more suitable for the rammed earth method than the small, smooth-grained soils. Heavy soils which contract markedly on drying and so would destroy a monolithic wall may frequently be used in the precast sun-dried units. One investigator reported certain soils which have a tendency to go through a process called "slacking" after puddling, that is, the soil crumbles as it dries or if subjected to heavy frosts. Such soils would appear to be wholly unsuited for building purposes.

The damp, rammed earth process appears to be less dependent on good drying weather and therefore capable of greater construction efficiency in the temperate zones than the wet sun-dried brick, poured earth or cob processes.

With the size and type of unit forms generally recommended for rammed earth construction, a three-man crew is required for greatest efficiency in dismantling and setting up the forms. Any number of men may work according to the equipment available but the special equipment necessary is considerably more expensive than that required by the other methods. The sun-dried brick method requires handling the same unit volume of soil three or four times more than in the monolithic processes, but is very easily adaptable to any sized working crew. With the poured adobe and cob processes the size of the working crew must be adjusted to the rate of drying of the completed work in order to secure greatest efficiency.

Persons interested in earth construction frequently exhibit decided preferences for a certain method. This preference is often for the rammed earth method and is usually based on the fact that it is "cleaner than the mussy, mud methods," or because it leaves a smooth wall surface which makes the wall finishing easy and economical.

Accurate, comparative costs of the various methods are difficult to secure. In one poured adobe farm house two

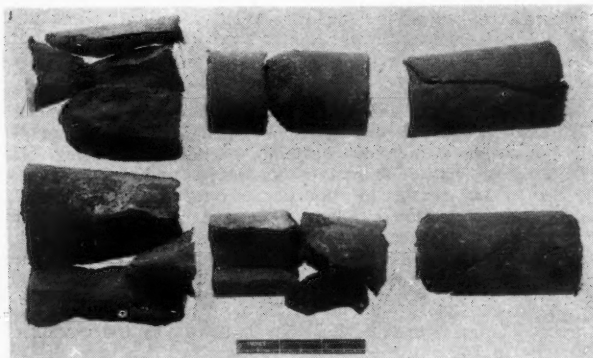
TABLE I. The Structural Strength of Puddled Soil Specimens

Soil series	Initial moisture content, per cent	Method of puddling	Moisture content when tested, per cent	Volume weight, lb. per cu. ft.	COMPRESSION		TENSION	
					Number of tests	Mean unit compressive strength, lb. per sq. in.	Number of tests	Mean unit tensile strength, lb. per sq. in.
Placencia loam	4.18	tamped	2.18	100.5	4	72.5		
	8.55	tamped	2.38	125.5	8	443.0	6	9
	14.17	worked	2.60	134.0	12	750.0	6	157
	26.02	stirred	2.20	125.0	13	785.0	6	86
Yolo fine sandy loam	10.90	tamped	3.40	104.5	2	190.0	6	31
	15.90	tamped	3.10	107.5	10	342.0	6	107
	28.90	worked	3.60	110.0	14	445.0	7	116
Yolo loam	12.90	tamped		106.0	3	158.5		
	11.30	tamped	4.40				6	25
	16.40	tamped	4.50				6	98
	29.10	worked	3.80				11	128
Hanford sandy loam	7.70	tamped	0.90	115.0	3	112.0		
	15.50	tamped	0.60	110.0	3	153.0		
	25.00	worked	1.10	103.0	3	109.0		
Holtville silty clay loam	9.40	tamped	1.60	94.2	1	60.0	6	15
	17.10	worked	3.50	114.0	1	95.0	6	75
	27.80	worked	4.20	106.0	8	500.0	5	97
Yolo clay loam	11.90	tamped	5.10	96.5	4	102.0		
	17.30	tamped	5.50	102.4	11	268.0		
	29.10	worked	5.70	93.0	14	570.0		

laborers raised the 18-in. walls for the 27x33-ft. structure an average of 6-in. per day. In sun-dried brick construction two laborers can make from 200 to 250 brick 4x12x18-in. in a day, and can lay from 250 to 300 in a day. Reports of rammed earth construction vary widely, due largely it would seem to soil differences, but the rate averages between 1 to 2 cu. ft. of wall per man hour. Compared to this the averages of the poured adobe and brick construction noted above are approximately 4.5 and 3.5 cu. ft. of completed wall per man hour, respectively. On a small experimental rammed earth structure where a pneumatic tamping equipment was used a speed of 7 cu. ft. per man-hour was obtained.

Soil Characteristics. Preliminary work has been done on the structural strengths developed by puddled soils. All of the methods of earth wall building require that the soil be thoroughly puddled as it is built up into the wall, in order to develop its structural strength. Heavy clay soils, particularly "adobe" and "gumbo" soils, are not suitable in any method of earth wall building unless mixed with sand or some lighter soil to counteract their tendency to excessive shrinkage. Much misunderstanding of this fact exists because soil surveyors have adopted the Spanish word "adobe" meaning "sun-dried brick" (the verb "adobar" means "to mix" or "to puddle") and have applied it to all soils which exhibit marked tendencies to expand when wetted and contract upon drying.

In specimens from six soil series which were mixed to



Typical failures of puddled soil specimens. The two in the center are of rammed earth

various moisture contents and tamped damp into the molds or worked into them from a mud consistency, the mean unit compressive strength ranged from 60 to 785 lb. per sq. in. In but one soil series, a sandy loam low in colloidal material, was the strength developed by the rammed earth specimens greater than that of the specimens molded from a mud consistency. In two clay loam series the resulting strengths of the tamped specimens was less than one-half that of the specimens molded from mud. This is shown in Table I.

An interesting study of the results of soil admixtures on rammed earth specimens is given in Table II. The results of a test of the effect of the shape of the tamping tool on the compressive strength of rammed earth specimens is shown in Table III. The soil used in both series of tests was a fine-grained, alluvial loam high in colloidal content.

The results of these tests do not accurately portray the field conditions of actual construction where the monolithic mud walls which have cracked in drying or the sun-dried brick laid up in mud mortar will have actual structural strengths less than those represented in these tests. All of the soils used gave compressive strengths sufficiently high to have a considerable factor of safety in supporting any ordinary roof load if built in walls twelve or more inches thick.

TABLE II. The Effect of Admixtures on the Compressive Strength of Rammed Earth Specimens

Soil series	Admixture	Initial moisture content, per cent	Volume weight, lb. per cu. ft. (air dry)	Number of tests	Mean unit compressive strength lb. per sq. in.
Yolo loam	None	12.9	106	3	158.5
	Sand (1:4)	13.2	116	5	167.8
	Gravel (1:4)	13.2	122	5	164.5
	Gravel (1:3)	14.3	124	3	108.0
	Hydrated lime	11.4	109	4	198.0
	Straw	12.0	107	6	284.2

TABLE III. The Effect of the Shape of the Tamping Tool on the Compressive Strength of Rammed Earth Specimens

Soil series	Tool	Volume weight, lb. per cu. ft. (air dry)	Number of tests	Mean unit compressive strength lb. per sq. in.
Yolo loam	Flat-faced tamper	96.7	3	91.8
	Wedge-faced tamper	104.5	7	130.3

Effects of Environment on the Dairy Cow and Its Relation to Housing¹

By M. A. R. Kelley²

IT IS an accepted fact that proper ventilation makes it possible to control the temperature in a well-built barn, and to modify the moisture content of the stable air. Hence, it is important for the agricultural engineer to learn how a change in the air conditions may affect the cow. It is not possible at this time to specify the optimum air conditions, but the following discussion should aid in obtaining the best results and stimulate further research.

Less than twenty years ago a leading authority in one of the New England states made the statement that the climatic conditions were too severe to permit of profitable winter dairying. Improved barns have made it possible for this to become one of the leading eastern states in milk production. Modern barns have made it possible to produce milk in any section of the country.

The modern farmer is not satisfied to house his cow in any kind of a shed and take what milk he can get, but houses his cow in a structure where she can be most comfortable in order that she may be induced to give more milk. Thus the cow is made to produce under artificial conditions, and it becomes necessary to study the effects of these conditions, and to learn how to control them properly.

The climatic conditions vary in the different localities, hence a structure which is suitable for one locality may not be the best or most economical for another section. Recent experiments made at the Indiana agricultural experiment station revealed that heifers housed in a barn gave more milk per day than those kept in open sheds. Experiments made at the Kentucky station showed that steers made bigger gains in a barn than in an open lot, and were more profitably fed. The Ohio station found that cows kept in the barn produced five per cent more milk with less feed than those exposed eight hours daily to the prevailing weather conditions.

Economic studies of eighty-eight farms in New York (1)* showed the cow produced the largest proportion of her annual production during the stabling period with an average of 3681 lb., or 18 lb. per day, and produced a total of 2624 lb. while on pasture, or at the rate of 16.3 lb. per day. Further study shows that greatest profits are made from the high-producing cow, and that winter dairying is the most profitable. The need for proper housing is thus apparent.

The major factors affecting environmental conditions are sunlight, temperature and humidity. The last two factors may be modified by ventilation.

Because sunlight is as free as the air we breathe few people appreciate its vital function in animal and human life. Science seems to have demonstrated that it is the ultra-violet rays in light that promote growth and vigor.

About seven per cent of the rays coming from the sun are known as ultra-violet rays; these are the rays which produce sunburn. About 80 per cent of the sun's rays produce heat, and 13 per cent produce light. It is now possible by means of an electric furnace to produce quartz on a commercial scale. This substance transmits ultra-violet rays readily and makes it possible to utilize them in experimental work. Certain forms of commercial glass possess this quality to a greater degree than common glass.

The beneficial effects of sunlight on livestock and poultry have been proved by experiments. Tests show that ultra-violet rays assist in the storage of calcium and phosphorus in the animal body. These are the main bone-building ele-

ments and their proper assimilation helps to prevent rickets, a common disease of young growing animals. Dr. Hughes, of Kansas State Agricultural College, demonstrated that crooked breast bones in chickens were the result of insufficient sunlight. Laying hens also suffer from insufficient sunlight and are unable to properly utilize the mineral elements in their feed. Hart and Steenbock of Wisconsin obtained an increase in the amount of calcium retained by the milking cow when exposed to sunlight as compared to those kept in the dark (2).

The temperature in the stable is dependent upon the heat produced and the heat conserved. There are many factors affecting heat production, but the principal factors are weight and amount of feed eaten. The heat conserved will depend upon the climatic conditions and the construction of the barn, with special reference to the amount of insulation used.

The feed that a cow eats is the source of body heat of which the first use is the maintenance of normal body temperature. Any surplus that is left will be used to produce milk, if she is a real dairy cow. However, there is a limit to the amount of feed a cow can eat and digest in a day.

A practical dairyman measures his success by the number of pounds of milk or fat that he can secure with the greatest net profit at the end of the month. That the environmental temperatures may affect this return is shown by results of experiments at animal nutrition laboratory of Pennsylvania State College (3), wherein it was found more profitable to keep the animal above the critical temperature than to force it to burn extra feed, or to draw upon body resources of energy in order to keep warm. Whatever the conditions as to profitable practice, it is important to know that a fall of 1 deg. F. in temperature below the critical temperature increases the cost of maintenance by about 1.5 per cent.

The critical temperature refers to the environmental temperature, and not to the temperature of the animal. The most comfortable temperature for the dairy cow is unknown, and varies according to the plane of nutrition. In the case of a fasting animal the heat resulting from the work of the internal organs may be regarded as incidental to the vital processes, and is available for maintaining the proper body temperature. This heat is sufficient if the thermal surroundings are at or above a certain external temperature. When the external temperature is below the critical point the fasting animal must katabolize some body tissue. The more feed the animal consumes the more heat is available, and the lower the external or critical temperature becomes. Thus the critical temperature not only varies with the kind and condition of the animal but also with the quantity and kind of feed consumed. Unfortunately we do not have definite information at present regarding these critical temperatures for cattle under different planes of nutrition.

However, Prof. Lee (4) reports an apparent relationship between the body temperature of man and his environmental temperatures even under ordinary conditions of living. He found the variation in rectal temperature to be about 1 deg. F. for 20 deg. change in atmospheric temperature. The body temperature was lowered by confinement in an atmosphere of 65 deg. and 50 per cent relative humidity and raised by confinement at 75 deg. with the same humidity, or still more at 86 deg. with 80 per cent humidity.

That milk yields and butter fat may be affected by variations in temperature and humidity is shown by the results of various investigations.

Henneberg (5) concluded that "In regard to respiration for every degree of temperature from 10 deg. C. (50 deg. F.) to freezing point 5 to 7 per cent more respiration material

¹Paper presented at the 21st annual meeting of the American Society of Agricultural Engineers, at University Farm, St. Paul, Minn., June, 1927. A contribution of the Committee on Ventilation.

²Associate agricultural engineer, U. S. Department of Agriculture. Mem. A.S.A.E.

³Numbers in parenthesis refer to the bibliography following this paper.



The modern farmer is not satisfied to house his cows in any kind of a shed and take what milk he can get from them but houses them in a structure where they will be comfortable, in order that they can be made to produce more milk. Thus they produce under artificial conditions, and it becomes the function of the agricultural engineer to study the effects of these conditions and to learn how to control them properly.

is needed, and for every degree increase 2 or 3 per cent less until 16.25 deg. C. (61.25 deg. F.) is reached. A higher temperature than 16.25 deg. C. is for many reasons unfavorable. Through sweating the stock will lose their appetite. The stable air becomes more impregnated with foul gases, carbonic acid, and odors from excrements when the temperature is high."

Rubner (6) states that when "The body temperature of warm-blooded animals is kept constant by the heat regulating mechanism or chemical heat regulation—which when the temperature falls produce an increase and, when it rises, a lowering of heat generation. The regulation operates very exactly. Air currents that are not even felt start it, and a variation of one degree in the temperature of the air can be experimentally demonstrated by the change in the consumption of food energy by the animal."

This is confirmed by the Pennsylvania experiments cited above. Hence it is not surprising that Spier (7) should have obtained from his test better results in the freely ventilated barns than with those where the ventilation was restricted. He reports two tests involving eight barns and 150 cows. Each barn was divided equally by means of a partition, and great care was taken in the selection of the cows so as to get equitable conditions. These experiments were conducted for a period of eighteen weeks. In the first lot of 100 cows he obtained in the freely ventilated barns, Section A, a total of 158,322 lb. of milk, averaging daily 27.5 lb. per cow, with a test of 3.55 per cent fat, at an average stable temperature of 49.8 deg.; in the restricted ventilated barns, Section B, 157,333 lb. of milk were obtained, with an average daily production per cow of 27.3 lb., and 3.49 per cent fat, with a stable temperature of 59.4 deg. Thus 989 lb. more of milk were produced in the freely ventilated barns. This result is obtained after the correction in milk yields were made for cases of sickness of the animals. In crediting the cows with milk an amount was assumed that would have been produced had she not been sick. Eight cases of mammitis were reported in the barns with restricted ventilation, and these cows are credited in the above amount of milk with approximately 400 lb. more milk than they actually produced, which would increase the difference between the two sections. Since it is not impossible that at least part of this sickness may have been due to the less favorable stable conditions in Section B, the question is raised whether this correction should be made in this comparison.

In the second test with 52 cows 1436 lb. more milk were obtained in Section A, the freely ventilated section, and

similar variations occurred with respect to the fat test, other conditions being similar to those in the first test.

The air in the freely ventilated barns contained 12 to 15 parts of CO₂ per 10,000, while in the sections with restricted ventilation it was as high as 100 parts of carbon dioxide per 10,000.

There is a steadily increasing amount of evidence which tends to show that there is a direct seasonal relation between milk yield and temperature within certain limits, and that there is an inverse seasonal relation between fat test and temperature. The early experiments of Drs. Jordan and Hill (8, 9 and 10) indicated these relationships, and they have been confirmed by more recent experiments. Some investigator attributed this seasonal relationship to change of feed from stabling period to the pasture season, but Prof. Dorsey found this same relationship to be true with the University of Maine herd which was stall fed the year around, so that there was uniformity of feeding. No soilage crops were fed until late in June, hence the pasturage factor was eliminated. He found the optimum barn temperature for milk production to lie between 50 and 80 deg. F.

The temperature of 80 deg. is given as the upper limit due to the fact that milk production decreased markedly above this temperature, and also the fat test decreased, indicating a depressing effect. No humidity readings were secured. On the other hand, when the temperature fell below 50 deg. there seemed to be an accompanying drop in production, while the fat test increased. However, it is obvious that this lower limit is bound to vary being affected by several factors. Spier (7) found that between 41 to 53 deg. temperature fluctuations have no appreciable effect on per cent of fat.

The general consensus is that cold weather is conducive to high fat tests and warm weather to low tests, and this without regard to breed, feed, or period of lactation.

Hays (11) quotes: "Echels in a study of 240 lactation periods of cows found that regardless of when the lactation began the percentage of fat was lowest during June and July, and gradually increased to the highest point in December and January, and then decreased again until midsummer."

Ragsdale and Turner (12) affirmed these results after a study of yearly records of 4100 cows including three breeds. Ragsdale and Brody (13) concluded from their study that there is a relation between temperature and percentage of fat, showing roughly an increase of 0.2 per cent in the fat for a decrease of 10 deg. F. in the temperature between the observed limits. Similar results were obtained by Dorsey (14) who reported a 0.1 per cent inverse variation in fat for

approximately a 4 deg. decrease or increase in temperature.

In a study (12) of the data of daily milk production of the dairy herd at the University of Missouri for a period of 258 days, the temperatures ranged from 85.5 to 24.5 deg. F. The average fat test ranged from 3.171 to 5.600 per cent. It was generally found that the lower the temperature the higher the fat test.

Later seven controlled temperature trials were run on two Jersey cows at temperatures of 10 deg. intervals with all other conditions remaining normal. The range of temperature was from 92.7 to 27 deg. F.

In these controlled temperature trials there was a constant increase in the per cent of fat as the temperature dropped below 70 deg. Above 70 deg. there was an actual increase in the fat test. The summary of these trials is shown in the accompanying table. It was concluded that temperature is a major factor in the variation of the per cent of fat in cow's milk.

Summary of All the Controlled Temperature Trials

Trial	Total number of days	Average temperature	Average daily milk, lb.	Average per cent fat
I	8	92.7	20.8	5.388
VI	4	80.0	21.6	5.227
II	6	72.5	20.5	5.149
V	4	60.9	21.0	5.424
IV	5	52.3	21.3	5.646
III	6.5	39.9	20.2	6.099
VII	5	27.0	18.4	6.012

These trials are of particular interest and serve as additional evidence to point out that the best temperature range for milk production lies between 40 and 80 deg. F. The largest yield of milk was obtained at Trial VI, while the largest amount of butterfat was obtained at Trial III. However, these trials do not include the effect of relative humidity, and to be complete this factor should be recorded.

Recent trials (15) reveal that there are three qualities of the air which determine a person's feeling of warmth: Temperature, humidity and air motion. One's body is always moist from perspiration, and hence experiences some cooling due to evaporation, which depends not alone on the temperature of the air but also on its moisture content. While the skin surface of the human body is always moist it is not as wet at the ordinary temperatures, and does not cool at the same rate as that of the wet-bulb thermometer. Hence neither the wet-bulb nor the dry-bulb thermometer is a true index for determining the degree of comfort. The Pittsburgh Research Laboratory (15) has developed a scale of effective temperatures wherein the three variables affecting warmth may be expressed as a single temperature equivalent to saturated temperatures. It was found that the comfort zone for a person normally clothed and slightly active was between 62 and 69 deg. effective temperature. An example will suffice to show the relation between effective, dry-bulb and wet-bulb temperatures. With the wet bulb and dry bulb at 68 deg., the effective temperature is 68 deg. Approximately the same effective temperature of 68 deg. may be obtained with a dry bulb temperature of 70 deg. and a relative humidity of 81 per cent, or a temperature of 72 deg. and humidity of 57 per cent, the same degree of warmth being experienced in each case.

There is reason to believe that a somewhat similar although unknown relationship exists with respect to the comfort zone of the cow. Careful investigations with this in mind are needed.

Gullickson (16) failed to find any noticeable effect of the

relative humidity on the percentage of fat in milk at ordinary temperatures. However, when high humidities and high temperatures were combined it appeared effective. With the temperature below 70 deg. and the relative humidity under 70 per cent the average test for 500 days milkings was 4.490 per cent, while with similar temperature and humidity above 70 per cent the average test was 4.437 per cent. When the temperature was more than 70 deg. F., and relative humidity less than 70 per cent, the average per cent of fat for 720 days was 4.404, and 4.298 per cent when the humidity was greater than 70 per cent. It is generally conceded that the cow gives the poorest quality of milk when the atmosphere is extremely hot and the air humid. Hence it appears that humidity has a qualitative effect although its quantitative relationship is unknown.

Rasmussen (17) is of the opinion that "There is an economic waste of fat from cattle being exposed to too much summer heat and dry winds. An influence in the same direction may be exerted by an excessively high barn temperature." A Danish writer (18) suggests that "Heat calls for an increased use of fat by the skin and hair of the animal, and thus withholds some fat from the milk." This apparent economic waste may be minimized by providing cool shelters for the cows during warm weather.

It should be remembered that insulation provided to keep a barn warm in winter will also help to keep it cool in the summer. In most barns the restriction of ventilation in order to attain a temperature of 60 deg. results in a degree of atmospheric impurity which is not consistent with conditions of perfect health. It is impractical to keep the average barn at such a temperature without excessive pollution. It is not necessary to keep cows outdoors in order to provide them with the fresh air necessary for the best health of the animal. This can be done in a properly built barn, equipped with a ventilating system suitable for the local conditions. The good dairyman sees to it that his cows are comfortably housed in a well-lighted and ventilated stable.

Bibliography

1. Economic Studies of Dairy Farming. New York Agricultural Experiment Station (Cornell) Bulletin 432.
2. Relation of Sunlight to Growth and Development of Calves. Gullickson and Eckles, Jour. Dy. Sc. Mar. 1927.
3. The Influence of Environmental Temperatures on the Heat Production of Cattle. E. B. Forbes et al. Jour. Agr. Research, Vol. 33, Sept. 15, 1926.
4. The Real Meaning of Fresh Air. Lee and Haldane, Jour. Am. Med. Assoc., Vol. 67, No. 14, pg. 1022-1023.
5. Influence on Production of the Temperature in Cow Barns, by E. O. Arenander. L. Andtannen, 1898.
6. On Formation of Body Mass in the Animal Kingdom and Ratio of Mass to the Consumption of Energy, by Max Rubner. Report of Prussian Academy of Science, 1924.
7. Influence of Temperature on Milk Yield. (Free vs. Restricted Ventilation), by John Spier, Kt. St. O. in Trans. of Highland and Agr. Soc. of Scotland, Fifth Series, Vol. XXI, 1909.
8. Effect of Weather on Quantity and Quality of Milk, by J. L. Hills, Vt. Sta. Bul. 23 and 30—Annual Rpts. 1891-1892.
9. Maintenance Requirements of Dairy Cattle, by J. L. Hills, et al. Bul. 225 and 226, Vt. Agr. Exp. Station, 1922.
10. Effect of Different Stable Temperatures Upon the Milk Yield of Dairy Cows, by W. B. Richards and E. L. Jordan. 21st Annual Report of Wis. Agr. Exp. Station, 1904.
11. Effect of Environmental Temperature on per cent of Fat in Cow's Milk. W. P. Hays, Jour. Dy. Sc. Mar. 1926.
12. Seasonal Variation in per cent of Fat in Cow's Milk, by Ragsdale and Turner. Jour. Dy. Sc. 1922, V, 544 and 1923, VI, 198.
13. Effect of Temperature on Percentage of Fat in Milk, by Ragsdale and Brody. Jour. Dy. Sc. 1922, II, 212.
14. Not published.
15. Air Conditioning Problems, by Houghten and Miller. Jour. Am. Soc. of Heat and Vent. Eng., Nov. 1926.



Three views of drainage ditches in the state of Montana that were blasted with dynamite.—Photos by courtesy of H. E. Murdock

Virginia Pays Tribute of Honor to McCormick

"CYRUS H. McCORMICK, inventor of the reaper, was born on this farm, February 13, 1809. Here he completed the first practical reaper in 1831. V.P.I. Student Branch, American Society of Agricultural Engineers, 1928." Thus reads the granite marker placed on the McCormick homestead in Virginia to apprise all visitors of its significance.

At the call of the student branch of the American Society of Agricultural Engineers at Virginia Polytechnic Institute more than one thousand people gathered on May 1, to witness the unveiling of the marker and pay a tribute of honor to this great pioneer agricultural engineer, Cyrus Hall McCormick.

Cyrus H. McCormick, son of the inventor; Cyrus McCormick, Jr., grandson of the inventor and vice-president of the International Harvester Company; Mrs. Cyrus McCormick, Jr.; the Rev. W. C. Taylor, Blacksburg Baptist Church; E. O. Fippin, secretary of the Virginia Conservation and Development Commission; and Dr. Julian A. Burruss, president, and H. L. Price, dean of agriculture of the Virginia Polytechnic Institute, attended and took part in the ceremony.

Charles E. Seltz, head of the Department of Agricultural Engineering at Virginia Polytechnic Institute, reviewed briefly the history of agricultural engineering and of the American Society of Agricultural Engineers. H. E. Lacy, president of the A.S.A.E. student branch, acted in the capacity of master of ceremonies.

The McCormick homestead which is still owned by the family is one mile west of Midway on Lee Highway, on the road to Raphine. The Virginia Conservation and Development Commission plans to place a marker at Midway which will call the McCormick place to the attention of tourists and send many visitors to the historic spot where the old buildings still stand and everything has been kept much the same as it was in the days of the inventor and of his father, Robert McCormick.

All of the speakers of the day called attention to the significance of McCormick's work. R. R. Choate, vice-president of the A.S.A.E. student branch, expressed it briefly and well in his address of presentation in which he said:

"Cyrus Hall McCormick, the great pioneer in the devel-

opment of farm machinery, invented the reaper in this old shop in 1831. His invention revolutionized methods of farming. This magic machine of the wheat field solves the mystery of prosperity. It explains the miracles of scientific agriculture and it accounts for the growth of great cities with their steel mills and large factories.

"Hard as it may be for the twentieth-century generation to believe, it is true that until recently the main object of all nations was to get bread. Life was a search for food—a desperate postponement of famine. Without this necessity of life, all our railroads, and skyscrapers, and automobiles could not save us from famine. If we had to reap our grain in the same way as the Romans did, it would take half the men in the United States to feed us on bread alone, to say nothing of the rest of the diet. With the hand cradle, every bushel of wheat produced requires three hours of a man's lifetime. Today, with our modern harvesting machinery, the time has been cut down to three minutes a bushel.

"We have failed to show our appreciation of this machine which has changed our entire mode of living. It has moved the civilized nations of the world out of the bread line. It has made prosperity possible and elevated the whole struggle for existence to a higher plane."

Expressing the attitude of Virginia toward the inventor and the McCormick family, Dr. Julian A. Burruss, president of the Virginia Polytechnic Institute, said in part:

"The old commonwealth of Virginia is happy that she may claim him as her son, but he was not merely a citizen of Virginia. He was also a citizen of America, yea more, a citizen of the world. His labors, following those of his father before him, and taken up and continued by those who have succeeded him, have brought results which are valuable beyond estimation to the entire world. The great organization now carrying on his work is truly named "International," for the sun never sets on its products, which are adding immeasurably not only to the physical well-being of humankind by supplying necessary food, but also to human happiness through release from toil."

Cyrus McCormick, Jr., vice-president of the International Harvester Company, pictured, in his address, some of the many interesting events and circumstances of his grandfather's life which show the character of the man and the trying



(Left) A partial view of the gathering which witnessed the unveiling of the McCormick marker. The building at the right is the old shop on the McCormick farm, in which the first McCormick reaper was built. (Right) Some of the important personages of the occasion. Standing, left to right, are E. O. Fippin, secretary, Virginia Conservation and Development Commission; H. L. Price, dean of agriculture, Virginia Polytechnic Institute; Dr. Julian A. Burruss, president, Virginia Polytechnic Institute; Mrs. Cyrus McCormick, Jr.; Cyrus McCormick, Jr., vice-president, International Harvester Company; Cyrus H. McCormick, chairman of the board, International Harvester Company; and Chas. E. Seltz, professor of agricultural engineering and head of the department, Virginia Polytechnic Institute. Kneeling, H. E. Lacy and R. R. Choate, president and vice-president, respectively, of the student branch of the American Society of Agricultural Engineers at Virginia Polytechnic Institute. (Photos by the Virginia State Chamber of Commerce.)

conditions under which he worked. Some particularly interesting paragraphs from his address are quoted as follows:

"Let us remember well that scene: A small field of ripened oats set off from the rich trees of the countryside by a rail fence; boys racing hither and thither, little dreaming that they were witnesses at the birth of modern agriculture; country farmers who saw in the young man's work some basis for the hope that their own tasks might be made lighter; idlers and sceptics sure that nothing different from that which always had happened ever could happen; slaves who little reckoned what this day was to mean to them in a time soon to come; brave souls and daring men, who, understanding nothing, nevertheless believed—and in a corner of the field the rude and homely machine that was to turn agriculture from drudgery into a science.

"Beside it stood a young man, anxious because of the bravado of his dream but clinging to hope because of the grandeur of his conception. An hour passes, and the machine is moving; another hour and it is cutting slowly in the grain; another hour and doubt vanishes; another—and mankind has added one more step in the progression from toil to triumph.

"Thus, in that hour and in this place, did Cyrus Hall McCormick take his stand beside the great men of all ages.

"The story of his epochmaking invention is too well known to call for retelling here, but I should like to refer to it briefly in order to emphasize some of the sterling points in my grandfather's character. The fact that he had made one machine work did not immediately solve the problem of producing quantities of machines for service in the wheat-fields of the world. Imagine the isolation and helplessness of that impecunious young son of a Virginia farmer, whose lack of capital alone was enough to bar him from commercial development of his ideas.

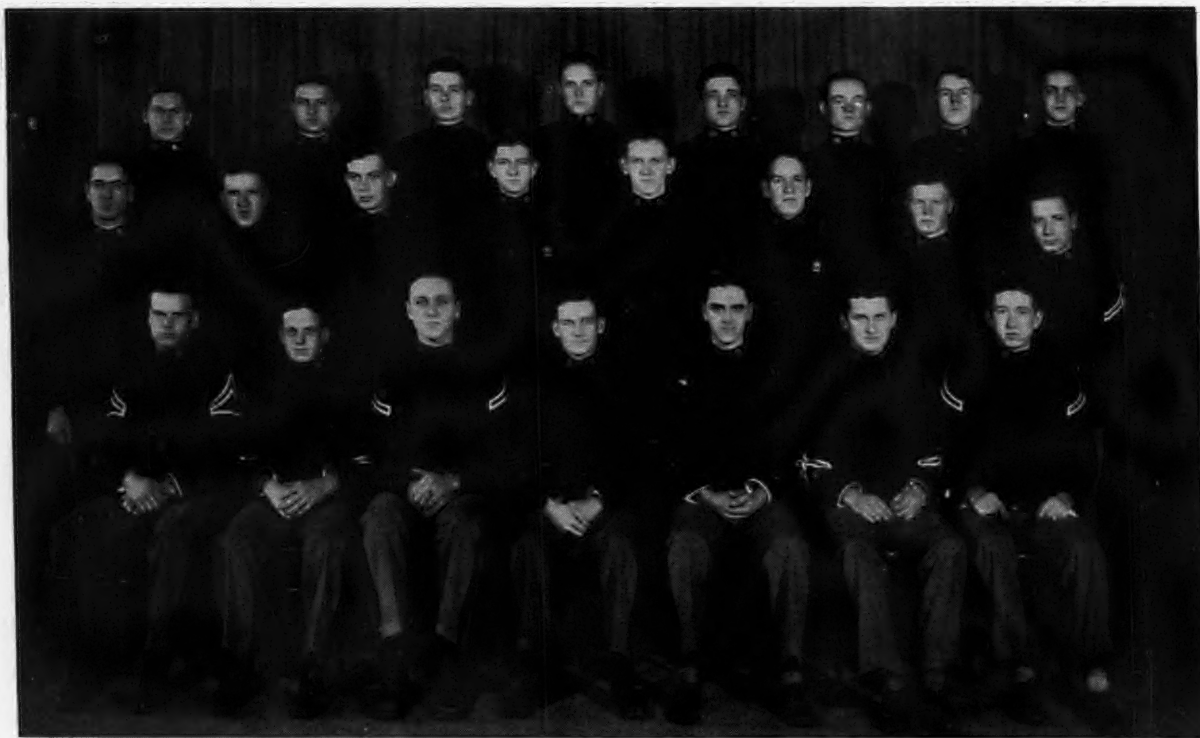
"Years of heroic effort, self-denial and hardship followed. During the shorter days of winter, when the roads were blocked with snow and mud, he would hew out of wood and forge from iron the various parts of his device.

Then when spring opened up the roads he would mount his horse, ride among his neighbors and try to sell them his machines. It was nine years before he sold a single machine—nine years of debt and discouragement, but never of defeat or even of doubt.

"In the first thirteen years after that memorable July day in 1831 he rolled up a sales total of just 89 reapers; but in the next two years the business passed out of the one-man stage. For the harvest of 1846 McCormick himself and small machine shops licensed by him in New York, Missouri, Ohio and Illinois turned out a total of 190 machines. This arrangement lasted only a short time, for even then the West was developing and this far-sighted inventor realized that the agricultural development of the country would be upon and beyond the great plains of the Mississippi valley. So in 1846 he decided to follow the path of empire westward and moved his tiny business to Chicago.

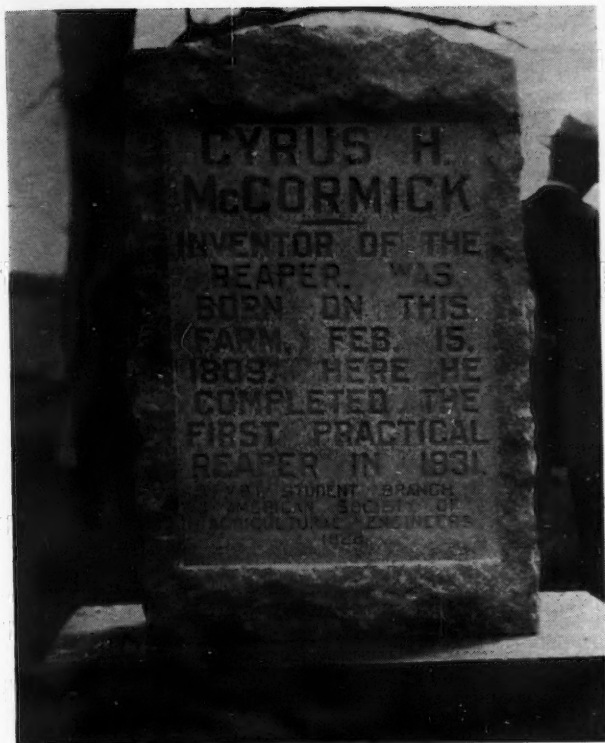
"Once established in Chicago young McCormick's business grew by leaps and bounds. It is perhaps a fortunate thing for civilization that one idea gives birth to others. As soon as McCormick had pioneered the invention of the reaper, other men sprang up to carry on with him the development of the first simple machine by the addition of labor-saving devices until, fifty years later, after its creation, the reaper was changed into the binder, or self-binding reaper that all the world knows today. Therefore, to the name of McCormick the industry added other resounding names of men who thought in practical terms and conceived still further ways of striking from the wrists of farmers the shackles of toil that prevented their full fruitfulness. These were men without whom the industry could not have developed as it has. But the fineness of their work adds to rather than detracts from the work of the original inventor. How well he wrought may be guessed when it is known that the seven cardinal points of the reaper of 1831 are to be found in the self-binder of 1928, unchanged in principle, little changed in application.

"When one of the early McCormick reapers was exhibited



Student Branch of the American Society of Agricultural Engineers at Virginia Polytechnic Institute

First Row (seated, left to right): C. J. Johnson, J. W. Weaver, H. E. Besley, H. E. Lacy, R. R. Choate, S. H. Byrne, B. F. Dyer. Second Row (standing, left to right): J. B. Billingsby, R. M. Trem'er, F. P. Trent, L. M. McGhee, J. H. Barker, K. Mustoe, C. M. Jones, F. Wise. Third Row (standing, left to right): E. W. Mundie, E. T. Swink, H. C. Maurer, Johns, J. D. Swan, F. L. Boccock, W. E. Steele, F. L. Yeatts. Members of the Branch not in the picture: R. L. Jones, C. R. Ellis, H. R. Linkous, W. N. Danner.



A close-up of the marker placed on the McCormick farm by the A.S.A.E. student branch of the Virginia Polytechnic Institute. (Photo by the Virginia State Chamber of Commerce.)

in England at the exposition of 1851 the British newspapers referred to the queer looking Yankee implement that was to replace the scythe as a cross between 'a chariot, a wheelbarrow and a flying machine.' But a few days later, when the full importance of the 'new contraption' of wood and iron was proved by a field test, the London 'Times' made voluntary and handsome amends; it contradicted its own words, saying that this same reaper was of more consequence to the world than all the rest of the exhibits—that it alone was worth the whole cost of the exposition. How true that was! The population of the world has been able to double

in the last century solely because men have provided means of acquiring food and clothing and transportation and work for the excess numbers.

"As our own west developed from waste prairies into fertile farm lands, the demands upon McCormick's factory and the similar shops of his competitors grew apace. Then came the Chicago fire of 1871, wiping out everything that McCormick had made. His first telegram to his wife after the holocaust is significant: 'There is no Chicago;' and her immediate action was typical of his and her methods of meeting emergencies. She took the first train to the stricken city and found him literally among the still burning embers of all he possessed, planning the rebuilding of his business and his fortune."

The action of the A.S.A.E. Student Branch in marking the place of McCormick's birth and early work are well explained in the closing remarks of Dean Price:

"I think it altogether fitting and proper that the V.P.I. students in agricultural engineering should take the initiative in erecting this stone, for where else could they look for greater inspiration than to this shrine? Who else than Cyrus Hall McCormick should be their patron saint? In honoring this great Virginian they honor themselves and fix their eyes upon a star that shall never grow dim so long as agriculture shall remain a basal industry. Here, the first great agricultural engineer with both brain and brawn succeeded in solving a fundamental agricultural problem. May his great achievement be a constant inspiration to these young men to the devotion of their lives and their efforts to the tasks that still remain undone!"

"The V.P.I. is proud to see her boys do honor to this great man. The institution is too young to claim any other connection with his work, but it is her privilege and her duty to see that the benefactors of American agriculture are not forgotten."

"This shrine is near enough to the seat of learning located at Blacksburg, Virginia, known as the Virginia Polytechnic Institute, to permit her agricultural students to give it perpetual and watchful care. After all, there is a tie of long standing between these two Virginia landmarks for I find in an old Blacksburg merchants daybook the following entry:

July 7, 1828

George Ahart

Dr.

To one McCormick plow.....\$10.00

"I would hazard the guess that this plow, in all probability built by young Cyrus Hall McCormick and his father, Robert, in this old shop, served to break the land where the great agricultural college of Virginia now stands."

Carbon Arc Lamps for Lighting and Irradiating Laying Pullets

LOWER mortality, increased gain in weight and increased strength of egg shells are indicated as effects of carbon arc lighting of laying pullets, as compared with ordinary Mazda lamp lighting, in a progress report of the Oregon Committee on the Relation of Electricity to Agriculture.

Five month's tests in cooperation with the Oregon Agricultural Experiment Station have been run by Geo. W. Kable and F. E. Fox to determine whether or not a low amperage, 110-volt, alternating current, carbon arc lamp could be used to obtain with one treatment the beneficial effects on laying pullets of day lengthening by artificial illumination and of ultra-violet irradiation.

Considerable difficulty was experienced in obtaining a lamp that would be low enough in first cost and operating expense, and reliable enough in operation to be practicable. A discarded Thomson enclosed multiple arc lamp was chosen, operated with 13 mm. therapeutic B carbons and adjusted to consume about 500 watts. It was burned as a flaming arc and supplemented by a 50-watt Mazda lamp. Carbon was consumed at the rate of 1½ in. per hr. and the arc gave considerable trouble from blowing out. While an enclosed globe would greatly reduce carbon consumption and

blowing out, none could be found which would resist heat and also transmit a large proportion of the ultra-violet rays.

The most striking effect of the carbon arc lighting was its apparent influence in decreasing the rate of mortality. Mortality in the Mazda-lamp lighted pen was 26.6 per cent and in the arc lighted pen, 10.4 per cent for the five months period. This is high in both cases but distinctly favors arc lighting. The general trend was toward a higher rate of mortality as the winter progressed, but this was not nearly so marked in the case of the arc lighted birds. A representative group of twenty pullets from each pen were weighed before and after the test. The gain in weight was 23 per cent for the arc lighted and 12.1 per cent for the Mazda lighted birds.

Preliminary tests on the strength of egg shells showed those from the arc-lighted pens to have a higher breaking strength. The number of eggs tested was not large enough to establish definitely the relation of light quality to shell strength.

Cost of operation for the arc lamps for six months was \$11.25 for 223 kw-hr. of electricity and \$14.40 for ninety-six 12-in. carbons. The two 50-watt Mazda lamps used in the other pens for the same period consumed 55 kw-hr., or \$2.75 worth of electricity.

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture. Requests for copies of publications abstracted should be addressed direct to the publisher.

Movable Hog Houses, W. A. Foster and W. E. Carroll (Illinois Station Circular 320 (1927)), pp. 20, figs. 30).—Suggestions relating to the planning and construction of movable hog houses are given, together with working drawings and bills of material.

Concrete-Work on the Farm, A. W. Hudson (New Zealand Department of Agriculture Bulletin 125 (1926), pp. 31, figs. 24).—Practical information on the use of concrete on New Zealand farms is presented.

Relation of Toilet Type to Typhoid Prevalence, K. W. Grimley (Public Works, 58 (1927), No. 11, pp. 425, 426, figs. 2).—Data are reported from Jefferson County, Ala., showing the numbers of typhoid cases where pit toilets, septic tanks, sewer connections, box and can toilets, and open toilets prevail. Of the 92 cases of typhoid reported in 1926, approximately 41 per cent occurred in homes served by box and can toilets, 24 per cent in homes served by pit toilets, 27 per cent in homes having open or surface toilets, and 8 per cent in homes served by sewers or septic tanks.

Comparative Strength Properties of the Principal Philippine Commercial Woods, J. C. Espinosa (Philippine Journal of Science, 33 (1927), No. 4, pp. 381-395, pl. 1).—In a contribution from the Bureau of Science, Manila, data from mechanical tests of some Philippine commercial woods are presented in tabular form and compared with Philippine mahogany. No conclusions are drawn.

Report on Heat Flow Through a Roof by Research Laboratory, F. C. Houghten (Journal, American Society of Heating and Ventilating Engineers, 33 (1927), No. 5, pp. 309-325, figs. 12).—Studies are reported which showed that heat flow meters can be successfully used to determine the flow of heat into a building during summer, and gives constants which check values on the same roof under more favorable conditions even under such varying conditions as when the direction of the flow may change every few hours. It was further found that heat flow into a building through an uninsulated roof in hot weather may be very great, and is an important factor in making the upper floors of such a building uncomfortably hot. The color and character of a roof surface are important factors in controlling heat absorbed through the roof of a building. It is considered possible under certain conditions to change the direction of flow from inward to outward.

The Action of Sulphate Water on Concrete, D. G. Miller (U. S. Department of Agriculture, Public Roads, 8 (1927), No. 9, pp. 203-213, figs. 8).—The results of further tests of specimens of concrete immersed in Medicine Lake, South Dakota, made by the Minnesota Experiment Station in cooperation with U. S. Bureau of Public Roads and the Department of Drainage and Waters of the State of Minnesota are presented and summarized (Agricultural Engineering, Vol. 8, p. 123). These tests have been conducted on concrete cylinders for periods up to 3.5 years.

The results indicate that standard portland cements from different manufacturing plants vary greatly in resistance. All cylinders of high alumina cements made satisfactory showings up to and including 3 years' exposure, with a few exceptions. The inference is that high alumina cements, while more resistant than standard portland cements, are, however, not of such high resistance as will permit the use of extremely lean mixtures for concrete subject to the action of sulfate waters. Specimens cured in steam at a temperature of 212 deg. F. continued to make excellent showings in all cases, and without exception, averaged stronger after 3 years' immersion than they did at one year. Such cylinders made equally favorable showings, irrespective of the brand of cement used in the mix. There was slight difference between the specimens cured in steam at 212 deg. and those cured at higher temperatures up to 285 deg.

The results appeared to indicate that certain admixtures, if properly handled, may have sufficient value in developing resistance to justify their use under special conditions.

Tested Methods for Waterproofing Concrete, F. E. Fogle (Michigan Station Quarterly Bulletin, 10 (1927), No. 2, pp. 63-67, figs. 2).—Data are reported on methods of waterproofing concrete, particularly for use in floors, foundations, and walls.

The Quantitative Effect of Engine Carbon on Detonation, N. MacCull and D. B. Brooks (Journal, Society of Automotive Engineers, 21 (1927), No. 1, pp. 59-63, figs. 7).—Studies are reported from which the conclusion is drawn that in making detonation tests carbon deposits should not be removed frequently, but that the engine should operate as much as possible under constant conditions. Tests should not be made immediately after removing the carbon, since the primary objection to carbon is its tendency to increase detonation. Carbon deposit tests should be superseded by detonation tests which will indicate the detonation inducing tendency of the carbon deposit. The effect of engine carbon is to increase detonation in proportion to the greatest thickness of carbon existing over any considerable area.

Digestion of Sewage Screenings, H. Heukelekian (Public Works, 58 (1927), No. 12, pp. 455-457, figs. 3).—Studies conducted at the New Jersey Experiment Stations are reported, the results of which indicate that the digestion of screenings either separately or in conjunction with fresh solids is feasible. The rate of digestion of screenings was found to be as rapid as that of the screened fresh solids, and the volume of gas produced from screenings was as high as that from fresh solids.

Agricultural Engineering Studies at the Illinois Station (Illinois Station Report 1927, pp. 204-222, figs. 6).—The progress results of a number of agricultural engineering studies are presented and discussed.

In connection with experiments conducted by E. W. Lehmann and F. C. Kingsley on the power consumption of electrically operated machines, data are reported on the total monthly energy consumption on ten farms.

With reference to farm septic tanks, the results of a five-year study by Lehmann and R. C. Kelleher indicate that a two-chamber septic tank will give the best results.

In the study of horse hitches, A. L. Young found that tractor plows can be pulled with horses satisfactorily. Apparently the tying-in and bucking-back system of driving can often be used to advantage on smaller tandem teams.

In a study of underdrainage in tight clay soils by Lehmann, F. P. Hanson and Kelleher in cooperation with the U. S. Department of Agriculture, it was found that laterals were quite effective in lowering the elevation of the ground water table when spaced 66 ft. apart, but when spaced 132 ft. apart were not effective midway between the tile lines.

In tests of soybean harvesting with combines, by Lehmann and I. P. Blausner, the importance of cutting close to the ground in order to reduce the loss of soybeans to a minimum was established. A tremendous loss was shown when the soybeans were cut as high as 6 in. above the ground.

In studies of corn drying by Lehmann, Kelleher, W. L. Burlison and G. H. Dungan, no advantage was indicated in using temperatures of more than 150 deg. F. The most economical temperature for evaporation was found to depend to a certain extent upon the design of the drying plant, the kind of fuel and power used, and the relative costs of fuel and power. From checks made on the germination of corn it appeared best to keep the drying temperatures for seed corn 10 or more deg. below 125 deg. F. for best results. The data indicate that a temperature of 190 deg. is distinctly harmful, and there is a suggestion that a drying temperature of from 130 to 150 deg. may be injurious. When the grain was dried to 12.5 per cent or less of moisture, the cobs were found to contain a smaller percentage of moisture than the grain. This is taken to indicate that the materials in the grain exert more pull on the moisture than do the materials in the cob.

A Study of Petroleum Lubricants, C. F. Mabery (Industrial and Engineering Chemistry 19 (1927), No. 4, pp. 526-529).—Studies conducted at the Case School of Applied Science are reported.

Two oils subject to heavy use were examined as to specific gravity, viscosity and behavior on a frictional bearing, and were found to have undergone little deterioration. Oils with the same viscosity showed wide variations in frictional tests. A series of medium grade lubricants with viscosity of 320 seconds at 38 deg. C. gave a maximum difference of 12 seconds at 98 deg., of 27 seconds at 54.4 deg. and corresponding differences in results on the frictional bearing.

Reinforced Concrete Construction.—Volume I, Fundamental Principles, G. A. Hool (New York and London: McGraw-Hill Book Co., 1927, 3. ed., pp. XII + 380, figs. 171).—This is the third edition of this book which lays down the fundamental principles of reinforced concrete design and construction and includes numerous tables and diagrams for use in calculation and design.

The Status of Rural Electrification in New Jersey, R. C. Oley (New Jersey Department of Agriculture Circular 112 (1927), pp. 32, fig. 1).—The results of a survey of the use of electricity on farms in New Jersey are presented and discussed. They indicate that rural service from central stations has been available only during the past five or six years. During that period the companies have made large strides into the country, and new rural extensions are being constructed constantly.

Dynamometer Test of Brake-Drum Heat in Dual Wheels, C. W. Bedford and E. Blaker (Journal Society of Automotive Engineers, 21 (1927), No. 2, pp. 100-170, figs. 15).—Comparative tests made of two disk truck wheels, one 20 in. and the other 24 in. in diameter, and of two 20-in. spoke wheels, are reported. Two cast steel brake drums were also used in the tests, which were similar in all respects except that one had surface corrugations extending from the flange part way across the outside of the drum and the other had substituted for these corrugations a strip of packing 1/32-in. thick.

A comparison of the four wheels on the basis of constant brake horsepower showed a wider difference in the same order than a comparison on the basis of constant brake drum temperature. It appeared that the greater the cooling action of a given wheel the greater is the error in comparing this with other wheels on the basis of constant brake drum temperature, and the greater is the necessity of a comparison on the basis of constant brake horsepower.

The cooling properties of a wheel were found to increase with the speed of rotation for a given brake horsepower input, and variations in speed did not materially change the relative cooling action of the three 20-in. wheels. Forced ventilation by external fans was found to be an aid in the dissipation of brake drum heat.

It is concluded that the tire trouble known as "burned beads" can not result from heat due to tire flexing, but must be attributed to brake drum heat caused by dragging brakes or excessive use of brakes. Excessive flexing in a tire due to under inflation, heavy loading or high speed will accentuate the effect of brake drum heat on the bead by decreasing the temperature gradient between the bead and tread.

Mutual Irrigation Companies in Utah. W. A. Hutchins (Utah Station Bulletin 199 (1927), pp. 51).—The results of a study of the history, operation, and utility of mutual irrigation companies, including incorporated companies and unincorporated associations in Utah, are presented. The study was made in cooperation with the U. S. Department of Agriculture, Bureau of Public Roads.

Grouping of Soils on the Basis of Mechanical Analysis. R. O. E. Davis and H. H. Bennett (U. S. Department of Agriculture, Department Circular 419 (1927), pp. 15, figs. 2).—This circular reports a study of soil classification on the basis of mechanical analysis, with a brief review of the literature and a comparative study of previous schemes. It is concluded that, inasmuch as the proportions of sand, silt, and clay in a soil sample can not be shown on a right-angled diagram, an equilateral triangle should be used, on which each of the components of a ternary mixture may be represented.

Practices and Costs of Cotton-Gin Operation in North-Central Texas, 1924-25. J. S. Hathcock (U. S. Department of Agriculture, Technical Bulletin, 13 (1927), pp. 60, figs. 16).—This bulletin gives the results of the analysis of cost and practice information obtained from 74 ginning businesses, mostly in Dallas and Ellis Counties, Tex. The investigation was made to ascertain the kind and quality of services rendered by gins, and to determine the factors influencing efficiency in gin operation. The businesses studied embraced 51 per cent of the native gins and 58 per cent of the bales ginned in the two counties during the year covered.

Ginning practices are discussed, including the location of gins, plant layout, ginning systems, labor requirements, management, charges, competitive practices, etc. The items of costs, income and profits are analyzed on the basis of size of plants, volume of cotton ginned per plant, type of power used and sources of income of the plants. Appendixes include miscellaneous tables on itemized costs of ginning and the articles of the Texas civil and penal codes affecting ginning operations, and discuss the methods used in the study in determining maintenance costs and capital investment.

Influence of Drainage in the Physical Properties and Mechanical Structure of Soil [trans. title], R. Janota ([Czechoslovakia] Min. Zemedel., Sborn. Vyzkumn. Ust. Zemedel. No. 16 (1925), pp. 142, figs. 30; Fr. abs., pp. 129-133, Ger. abs., pp. 134-138).—Studies of the effect of tile drainage on the physical and mechanical properties of slightly podsolized brown soils and heavy soils with marl subsoils are reported. Ninety soil profiles were studied to a depth of one meter under drain spacings of from one to three meters.

The structure of the soil type was found to be a function of movement of water through the soil. The downward movement of drainage water causes the concentration of the finer soil particles and soluble electrolytes in the subsoil. The difference between the contents of fine particles in surface and subsoils was found to be 10 per cent in loam soils and 20 per cent in heavy soils. Thus natural drainage may account, in large measure, for the high content of cementing materials and the low porosity and poor ventilation of subsoils.

Artificial drainage was found to remove excess water from soil and by improved ventilation to cause the stabilization of colloidal material in the top layers. In artificially drained soils the contents of fine particles and carbonates in the surface soil were found to increase from the drain to the middle point between drains. At the same time the porosity decreases with increasing spacing of drains. In the subsoil the content of fine particles and carbonates is the greatest with the lowest porosity, and the former decrease from the drains to the middle point between drains while the porosity increases. Thus the subsoil presents the poorest structure under drainage, especially in heavy soils.

Artificial drainage causes rapid changes in the physical properties of surface soils. This effect decreases with depth until in the subsoils these changes almost disappear, especially in heavy soil types.

The production and maintenance of a crumb structure were more difficult in heavy soils than in loam soils under drainage, and liming may be resorted to after drainage to aid this situation.

The Fatigue of Metals. H. F. Moore and J. B. Koppers (New York and London: McGraw-Hill Book Co., 1927, pp. XI + 326, pls. 2, figs. 102).—This book summarizes the more important experimental facts concerning the strength of metals under repeated stress, reviews briefly the more important of the current theories

of fatigue of metals and briefly describes apparatus and methods used in making an experimental study of the fatigue of metals. It contains chapters on stress and strain in metals—the accuracy of the ordinary concepts of elastic action; historical survey up to 1919—fundamental concepts; slip, overstrain and hysteresis; fracture under repeated stress; testing machines and specimens for fatigue tests of metals; characteristic results for fatigue tests; the effect of range of stress on fatigue strength; "stress raisers" and their effect on fatigue strength—stress and corrosion; fatigue failure under service conditions; fatigue of wood; and fatigue of cement and concrete. A bibliography is included.

The growing use of high speed machinery in agricultural practices makes this book one of special importance to agricultural engineers.

Stream Gaging. W. A. Liddell (New York and London: McGraw-Hill Book Co., 1927, pp. XIV + 238, figs. 137).—This book contains chapters on the flow of water in rivers, distribution of velocities in open channels, stream gauging stations, gauges, channel area, floats and float measurements, current meters, rating the current meter, current meter characteristics, current meter measurements, slope and weir measurements, construction and use of station rating curve and effects of ice on stream flow.

The Future Development of Washing Machines [trans. title], O. Neumann (Gsndts. Ingen., 50 (1927), No. 34, pp. 613-619, figs. 5).—The history and future development of domestic washing machines to meet German conditions is discussed.

The Effect of Lime on the Physical Properties of Soils (Nebraska Station Report [1926], p. 15).—Lime did not appear to increase the moisture intake during wet periods, but showed a slight conservation effect during dry periods. In cans of soil exposed out of doors for two seasons lime did not increase the percentage of pore space, but made the soil more friable. Lime with manure, however, or manure alone considerably increased the pore space and rendered the soil ideally friable. Lime only slightly lowered the plow draft, but considerably reduced the force required to shear or cut the soil. Lime altered neither the scouring point nor plastic properties, but reduced the toughness of soil when wet and its hardness when dry. The stability of soil granules was not increased by lime alone but was increased considerably when lime and organic matter were both added.

Cleaning Grain on Farms and in Country Elevators. R. H. Black and E. G. Boerner (U. S. Department of Agriculture, Farmers' Bulletin 1542 (1927), pp. II+27, figs. 19).—This bulletin supersedes Farmers' Bulletin 1287 entitled "Foreign Material in Spring Wheat."

The Financing of Non-Governmental Irrigation Enterprises. R. P. Teele (Journal Land and Public Utility Economics, 2 (1926), No. 4, pp. 427-440).—The historical development of non-governmental irrigation enterprises is described briefly. The defects of the Carey Act and the weaknesses of the irrigation district legislation of different states are pointed out, and the security back of irrigation bonds and the proposals for remedying the weaknesses of the district plan are discussed.

Storage Tests with Sugar Beets [trans. title], S. Kudelka and E. Scholtz (Ztschr. Zuckerindus. Cechoslovak. Repub., 51 (1927), Nos. 32, pp. 347-351, figs. 3; 33, pp. 365-368; abridged in Facts About Sugar, 22 (1927), No. 20, pp. 486, 487).—Experiments were made to determine optimum storage conditions and the relative merits of different forms for piles of sugar beets. Beets containing about 17 or 18 per cent of sugar and weighing about 600 gm. each were stored in prismatic earth covered piles (a) 4 meters wide at the bottom, 2.7 meters wide at the top and 3.3 meters high and ventilated, (b) of the same dimensions but unventilated; and (c) 4 meters wide at the bottom, less than 1 meter at the top and 2.2 meters high, unventilated. Observations were made on beets inclosed in nets at different levels in the piles. The outside temperature during the test period, October 12 to November 21, averaged 11 deg. C. (52 deg. F.), ranging from 22.5 to -2 deg.

Observations on sugar losses, changes in the weight of beets, and temperatures at the test points indicated that temperature was the prime factor in keeping piled beets, temperatures as low as possible being desirable. Small piles protected from frost seemed more advantageous because the heat is dissipated naturally, whereas large piles, more easily protected against frost, are subject to considerable sugar loss in warm weather, although with proper ventilation they could combine the advantages of both large and small piles. Excessive aeration helped to increase sugar losses, but this was outweighed by benefits derived from the lowered temperature. The temperature rose toward the top of the pile.

During the first 14 days in other tests poorly topped beets exhibited no noteworthy losses of sugar, but during the 3 weeks following the loss exceeded that in well topped beets, suggesting that a process of continued ripening takes place when the beet has been improperly topped. Later on sprouts appear and use up considerable sugar for their vegetative growth. Small beets (averaging 236 gm.) seemed to have better keeping qualities than large beets (806 gm.). However, it was observed that in topping the larger beets are relatively the more damaged. In these investigations high quality beets rich in sugar did not keep as well as those with lower sugar contents. Practical suggestions derived from the experiments are outlined for the storage of sugar beets.

AGRICULTURAL ENGINEERING

Established 1920

A journal devoted to the advancement of the theory and practice of engineering as applied to agriculture and of the allied arts and sciences. Published monthly by the American Society of Agricultural Engineers, under the direction of the Publications Committee.

PUBLICATIONS COMMITTEE

R. W. Trullinger, Chairman
J. B. Davidson F. A. Wirt
G. W. Iverson P. S. Rose

The Society is not responsible for the statements and opinions contained in the papers and discussions published in this journal. They represent the views of the individuals to whom they are credited and are not binding on the Society as a whole.

Contributions of interest and value, especially on new developments in the field of agricultural engineering, are invited for publication in this journal. Its columns are open for discussions on all phases of agricultural engineering. Communications on subjects of timely interest to agricultural engineers, or comments on the contents of this journal or the activities of the Society, are also welcome.

Original articles, papers, discussions, and reports may be reprinted from this publication, provided proper credit is given.

RAYMOND OLNEY, Editor

No Bigger Than Its Engineering

THE engineering of an industry is a tremendous task. Even in the case of a new industry it is a big undertaking, but with an old established industry it is many times more difficult. Except agriculture, engineering was applied to the major industries comparatively early in their development; therefore, less resistance was encountered and progress has been rapid. But agriculture—the oldest, the largest, the most basic—is the last of the larger industries, and the most difficult, to put on a basis of sound engineering.

Have patience, agricultural engineers, your job is a big one and a hard one and a long one!

When your group of ambitious pioneers met back there in December 1907 at Madison, Wisconsin, and had the temerity to call themselves "agricultural engineers," probably not one of them saw the future of this branch of engineering as he sees it today. It has come a long way in the two decades that have since elapsed, and considering the nature and extent of the obstacles that have had to be overcome, it has made wonderful progress.

It may be said that agricultural engineering is just beginning to come into its own—from the standpoint of its acceptance by the general public, or at least that portion of it which is competent to grasp its significance and to foresee that agriculture to be on a par with other industry must employ the same means. But even with the much larger measure of general acceptance which the profession enjoys today, the agricultural engineer must still fight his way over a long road of precedents and orthodoxies. However, a good start has been made, and there is every reason to believe that the going will be easier and that faster progress will be made from now on.

It is encouraging to find persons in high positions recognizing the place and importance of agricultural engineering, as many are now doing. For example, just recently during a meeting of the North Central Section of the American Society of Agricultural Engineers at Iowa State College, President Hughes of that institution is quoted as saying, in addressing those in attendance, that, in his opinion, agricultural engineering is just as stable a branch of the engineering profession as civil engineering, or any of the other branches. "You agricultural engineers," he said, "hold one of the most important keys to the development of this country."

Agricultural development in America is in most respects very much in advance of that in other parts of the world,

but compared with many of the other industries in this country it is very much underdeveloped. A great deal of thought is given these days to bringing agriculture up to the level of other industries. What is the answer?

The answer is largely engineering. Agriculture in this country will either become merely an occupation for a peasant class of people, or it will become "industrialized;" it cannot stand still. It would seem, however, that there is but one direction for this development to take, and that is toward greater industrialization. All of which means engineering—along with management and finance. The present generation has stood in awe of the tremendous engineering developments that have taken place in the manufacturing industries; the next quarter century will witness just as big, just as far-reaching developments in the engineering of agriculture.

Indeed agriculture is no bigger than its engineering!

Our Field

AGRICULTURAL engineering is not an offshoot of a particular branch of engineering. Neither is the American Society of Agricultural Engineers a division of another engineering society that has declared its independence and set up its own organization.

Agricultural engineering is the application of all the fundamental branches of engineering—civil, mechanical, electrical, chemical—to the industry of agriculture. As distinguished from the "fundamental" branches, agricultural engineering is one of the "industrial" branches of engineering. It is comparable to mining engineering.

There is practically no conflict between the function of the strictly agricultural engineer and that of other engineers, in either the fundamental or industrial branches. Likewise the particular field of the American Society of Agricultural Engineers is quite distinct from that of any other engineering society, and for the most part the dividing line between most of the branches of agricultural engineering and other phases of engineering has been well defined.

At the same time agricultural engineers recognize the desirability of closer contact and cooperation with other engineering groups. Especially is such cooperation to be encouraged between agricultural engineers and the specialists in other fields—scientists, as well as engineers—on specific problems.

It is important that agricultural engineers keep in mind the true relationship of agricultural engineering to other branches of engineering, especially so far as the scope and activities of the American Society of Agricultural Engineers are concerned. The Society will not encroach upon the field of other societies, and by the same token it insists on being recognized as supreme in its own field. This, however, does not affect the individual member; naturally he is free to be active in any or all fields of engineering. But if his work is predominantly in the agricultural engineering field, he is considered as being an agricultural engineer.

Early Uses

Secretary, A.S.A.E.:

IN LOOKING over a report for 1902 of the Department of Parks, City of New York, relative to Central Park, the following notation is found on page 10:

"In 1857 Mr. Olmstead was appointed superintendent to the Board, and George E. Waring, agricultural engineer."

Of course, most of us knew from C. G. Elliott's book "Engineering for Land Drainage" of Col. Waring's connection with this work, but I believe this is one of the first instances where the term "agricultural engineer" was used.

JOHN R. HASWELL

This bit of history is interesting. Perhaps there are other members of the American Society of Agricultural Engineers who have dug up early uses of the term "agricultural engineer." If so, it is suggested that they be sent to the Secretary's office as a matter of general interest.—Secretary, A.S.A.E.

Who's Who in Agricultural Engineering



Wm. Boss



Geo. S. Knapp



W. C. Harrington



Geo. W. Kable

Wm. Boss

William Boss (Charter A.S.A.E.) is the president-elect of the American Society of Agricultural Engineers. He is professor and chief of the division of agricultural engineering at the University of Minnesota. He was one of the first teachers of agricultural engineering subjects in an agricultural college and is a charter member of A.S.A.E. Mr. Boss has been connected with the University of Minnesota most of the time since 1890, when he entered as a student, with the exception of eight years from 1910 to 1918, when he organized and developed The Specialty Manufacturing Company of St. Paul, manufacturers of hardware specialties. He was called back to the University during the war period in 1918 and served one year on a half-time basis. Since 1919 Mr. Boss has given all his time to the division of agricultural engineering. Under his direction a professional course in agricultural engineering was inaugurated in 1925. Mr. Boss has always been keenly interested in farm labor-saving problems and in the building of better farm houses. Largely through his efforts the Minnesota state legislature appropriated funds for the agricultural engineering building at University Farm in 1910. He was chairman of the A.S.A.E. College division in 1926, and chairman of the 1927 Meetings Committee.

Geo. S. Knapp

George Knapp (Mem. A.S.A.E.) was recently elected to the office of first vice-president of the American Society of Agricultural Engineers, to serve for one year, from June 1928 to June 1929. His regular job is that of chief engineer of the Division of Water Resources of the State of Kansas. Mr. Knapp is a native of Kansas and is a graduate of the Kansas State Agricultural College, with a degree in mechanical engineering. Upon graduation in 1914 he was appointed an irrigation engineer of the U. S. Department of Agriculture, which position he held for about one year. In 1915 he was made superintendent of the Kansas State Irrigation Experiment Station at Garden City; this position he held for about four years. In 1919 he was appointed to the office of state irrigation commissioner, which position he held until about one year ago, when he was promoted to his present position.

Mr. Knapp is recognized as one of the outstanding irrigation engineers in the irrigated sections east of the Rocky Mountains. He has devoted special attention to the problems of irrigation pumping from wells and has made some notable contributions to that subject.

During 1926-27 Mr. Knapp served as vice-chairman of the Reclamation Division of the A.S.A.E., and during the present Society year he has served as chairman of that division.

W. C. Harrington

W. C. Harrington (Mem. A.S.A.E.) was recently elected to the office of second vice-president of the American Society of Agricultural Engineers, to serve from June 1928 to June 1929. When the North Atlantic Section of the Society was organized in 1925, Mr. Harrington was elected as its secretary-treasurer. He held this office until his election last October as chairman of the Section. He rendered outstanding service as secretary of the Section especially in the direction of building up a large membership.

Mr. Harrington is a graduate in mechanical engineering from Cornell University. Upon graduation he entered the employ of the New York State Commission of Highways as highway engineer and retained that position until the United States entered the World War. During the war he was commissioned first lieutenant of engineers serving under the Chief of Engineers with the A.E.F. in France, where he was engaged in the manufacture of portland cement for the army. Since 1921 Mr. Harrington has been associated with the Portland Cement Association as field agricultural engineer in the New York district. In his present connection he has made a special study of concrete as applied to farm structures and to sanitary projects.

Geo. W. Kable

George Kable (Mem. A.S.A.E.) was recently elected a member of the Council of the American Society of Agricultural Engineers, to serve for a term of three years, from June 1928 to June 1931. He holds the position of agricultural engineer of the Oregon Agricultural Experiment Station, and is also project supervisor for the Oregon Committee on the Relation of Electricity of Agriculture. He is an engineering graduate of the University of California. His activities in the field of agricultural engineering since graduation include the following: Member of the experiment station staff and acting head of irrigation department at the New Mexico College of Agriculture and Mechanic Arts; engineer for the Mesilla Valley Ditch Company; engineer and manager of large ranches in New Mexico; and for eleven years past in the state of Oregon as county agricultural agent, extension specialist in drainage, extension specialist in land clearing, extension specialist in agricultural engineering, and now agricultural engineer of the experiment station and project director of the Oregon C.R.E.A. Mr. Kable's A.S.A.E. activities, in addition to the contribution of a number of outstanding papers on agricultural engineering subjects, consist of membership on the land clearing, drainage, and extension committees. He is at present a member of several A.S.A.E. committees.

A. S. A. E. and Related Activities

North Central Section Meeting

MEETING at Iowa State College on May 18 and 19 the North Central Section of the American Society of Agricultural Engineers celebrated its first birthday.

Last year at about this time nineteen of the leading agricultural engineers of the Dakotas, Nebraska, Kansas, Missouri, Iowa and Minnesota met at Brookings, South Dakota, organized and petitioned for recognition as the North Central Section of the Society. The petition was granted. More than three times that number attended the recent meeting of the Section and enjoyed the excellent program.

Those who came in for Friday evening, May 18, found the college in the midst of its annual "Veishea" celebration. On this occasion the whole college is on display and the visitors, under the guidance of E. M. Mervine, of the department of agricultural engineering, made a tour of the various buildings and departments that evening.

J. B. Davidson welcomed the group to Ames and the state college at the opening of the meeting Saturday morning. The "combine" was the center of the discussion for the first part of the morning. J. F. Goss, agricultural engineer, South Dakota State College, talked on "The Machine in the Field" and R. H. Black, agricultural engineer in charge of U.S.D.A. grain cleaning investigations, talked on "Storing and Handling Combined Grain." In the absence of R. H. Driftmiller of Kansas State Agricultural College, E. A. Stewart, secretary of the Section, read the paper on "Combines in Kansas" which he sent. M. M. Jones, agricultural engineer, University of Missouri, discussed "Combines in Missouri."

A. W. Clyde, agricultural engineer, Iowa State College Extension Service, discussed "Extension Projects Needed to Meet the Combine Situation." He pointed out that successful projects are built around simple solutions to specific problems of general interest. It was his opinion, and that of others present, that no extension work would be needed to introduce the combine, but that when it came into more general use, problems on its operation, care and adjustment would undoubtedly develop and furnish a logical opportunity for extension work.

"Weed Control," a paper by R. H. Black, was heard with a great deal of interest. Arthur Huntington, public relations engineer for the Iowa Railway & Light Corp., called attention to the interest of the U. S. Chamber of Commerce in the subject.

Mason Vaughn, agricultural engineer, Allahabad Agricultural Institute, Allahabad, India (now studying at the University of Missouri), reviewed some of the interesting phases of his research work on "Reinforced Brick Beams."

At the noon luncheon furnished by the men of the agricultural engineering department at Ames, the agricultural engineers received a great deal of encouragement from President R. M. Hughes, of Iowa State College, A. Marston, dean of engineering, and Dr. W. H. Stevenson, vice-director of the Iowa Agricultural Experiment Station.

Dr. Stevenson said, "I am not an agricultural engineer, I'm a crops and soils man, but I'm glad to be here because we need you so badly. In our work we are continually running up against problems which we must depend upon the agricultural engineer to solve. For example, right now we need a good fertilizer attachment for drills; a plow that, in plowing sweet clover, will cut off absolutely all of the roots; a fertilizer distributor attachment for disk harrows; and a machine which will mix fertilizer with straw as it comes out of the thresher, to make artificial manure."

Dean Marston, who gave his loyal support to agricultural engineering before it was even recognized as a branch of the engineering profession, and who owns a dairy farm in northern Iowa, remarked, "It looks like agriculture is considerable of an engineering proposition when an engi-

neer from Cleveland, Ohio, comes out here, inspects my plant and leaves a little red card saying 'Build a new milk house.' At any rate he did, and I did."

President Hughes told the agricultural engineers, among other things, "I do not see but what agricultural engineering is just as stable a branch of the engineering profession as civil engineering, or any of the other tranches. You agricultural engineers hold one of the most important keys to the development of the country."

At the chemical engineering laboratory shortly following the luncheon Dr. O. R. Sweeney introduced the subject of corn stalk utilization by pointing out some of the social and economic aspects of the commercial development in this field which may take place in a few years. Then he showed and explained points about a number of the most interesting and promising of the many chemical and fibrous materials which he has made from corn stalks. Concluding his talk, Dr. Sweeney showed the group the various digesting tanks, pumps, rollers, ovens, presses, and other machinery with which he converts the humble corn stalk into building materials as soft as cork or as hard as marble and into various liquids for which there are hundreds of uses.

A little distance from the chemical engineering laboratory stands a stack of baled corn stalks that would fill a good sized barn. Back in the agricultural engineering building, E. V. Collins, agricultural engineer, Iowa State College, told how they were harvested and the difficulties met and overcome in connection with this unusual harvesting problem.

Demonstration and inspection, during the middle of the afternoon, of research projects at Iowa State College included: "The 'L' Concrete Block," by J. B. Davidson; "Poultry Ventilation," by Henry Giese; and "Experimental Machinery" by E. V. Collins.

Following these demonstrations E. M. Mervine gave a paper on "Teaching Methods in Farm Machinery" which was discussed by A. J. Schwantes, agricultural engineer, University of Minnesota.

Chairman Ralph L. Patty, agricultural engineer, South Dakota State College, called a short business meeting at which E. M. Mervine was elected chairman, M. M. Jones, agricultural engineer, University of Missouri, vice-chairman, and H. B. White, agricultural engineer, University of Minnesota, secretary-treasurer of the section for the coming year. A report of the outgoing secretary-treasurer showed a favorable balance in the treasury of the Section. A resolution was passed expressing the thanks of the Section to the members at Ames for their hospitality.

A rural electrification session was held in the evening. E. M. Mervine, incoming chairman, presided.

E. A. Stewart, agricultural engineer, University of Minnesota, talking on "Investigations on Rural Electrification," emphasized the great need of continuing these investigations. "Grinding Feed with Electric Power" was the title of a paper by F. J. Zink, agricultural engineer for the Iowa Rural Electric Project at Garner, Iowa.

The work and responsibility of the commercial rural electric service man was clearly pointed out by C. P. Wagner of the Northern States Power Company. Both Mr. Wagner and the company he represents stand among the pioneers in developing rural electric service.

"Problems of Rural Electrification in Iowa" by G. E. Grunewald, agricultural engineer, Iowa Railway and Light Corp., was the concluding number on the program. Mr. Grunewald told of many interesting experiences in his contact with farmers, and pointed out the importance of seeing that equipment sold to the farmer is properly installed and adjusted to give complete satisfaction and make the use of electricity profitable to him.

The meeting was adjourned after a brief discussion.

A.E.S.C. Changes Procedure to Speed National Standardization

EXTENSION revision of its rules of procedure to speed industrial standardization work on a national basis is announced by the American Engineering Standards Committee. The chief object in broadening the procedure has been to make it so flexible that it may easily fit all of the varied conditions to be met in the wide range of industrial subjects covered by the Committee's work; the revision is based on its experience during the nine years of activity as a national standardizing body.

Three important changes are made in the procedure. Heretofore each sectional committee—essentially a joint committee composed of representatives of the various groups interested in the particular work in hand—has acted under the administrative support and direction of one or more of the interested bodies, who are termed "sponsors." A sectional committee may now operate autonomously, reporting directly to the A.E.S.C.; or it may act under sponsors as before. The second change recognizes "proprietary" standards and makes possible the revision of such standards within a single organization on condition that it be shown that a standard is acceptable to the groups concerned. This method is particularly applicable to highly specialized fields in which the standard of an organization has already achieved a position of recognized eminence. The third change provides for very simple cases. The approval of standards under such cases is based upon the action of a conference followed by written acceptances of the interested groups.

The revised procedure states that the different methods are founded on the principle that the basic test to be applied in all cases is the fact of the assent, affirmatively expressed, of the groups having substantial interest in the standard. Such groups have an inherent right to representation on the body dealing with the subject matter of the standard, but it is not essential that this right be exercised.

The steps in the development or revision of a standard by a sectional committee are:

1. Standardization proposed by a responsible body.
2. General conference called by A.E.S.C. to consider the proposal and to decide whether the work shall be done; if so, whether the sectional committee shall operate under a sponsor or autonomously.
3. Recommendation of conference acted upon by A.E.S.C.
4. A sectional committee is organized.
5. The make-up and personnel of sectional committee approved by the A.E.S.C.
6. Standard drafted by sectional committee.
7. The draft standard published or circulated for criticism.
8. Proposed standard approved by sectional committee by letter ballot.
9. Proposed standard approved by sponsor, if there be a sponsor, or formally endorsed by at least one cooperating body if the sectional committee is autonomous.
10. Standard approved by A.E.S.C.
11. Standard published by sponsor, or by the A.E.S.C. if sectional committee is autonomous.

The following are the steps in the approval of existing or proprietary standards:

1. An existing or a proprietary standard submitted to A.E.S.C. for approval by a responsible body.
2. Investigation of facts regarding consensus through A.E.S.C. agencies; or the development of the acceptability of the standard through a representational committee.
3. Standard approved by A.E.S.C.
4. Standard published.

The following are the steps in the development of a standard by general acceptance:

1. Standardization proposed by a responsible body.
2. Survey of field made, and draft standard produced by working committee.
3. Draft standard considered by general conference.
4. Proposed standard formally accepted by groups concerned.
5. Standard approved by A.E.S.C.
6. Standard published.

The governing authority of the American Engineering Standards Committee is at present vested in 63 men representing 36 national organizations—industrial, technical and governmental. About 350 national organizations are officially cooperating in the work, with 2100 individuals engaged on various committees. Up to the present time 111 national standards have been approved, and 164 additional projects representing almost all branches of industry are under way.

"Preferred Number" Basis of Standard Sizes

AFAR-REACHING step toward the gradual elimination of huge wastes in industry and commerce through the replacement of hundreds and often thousands of needless sizes of products in common use by a few scientifically selected sizes, is announced by the American Engineering Standards Committee following a two-year study of the problem by a special committee of scientists and engineers. The report of the special committee recommends a scientific system of sizes—called "preferred numbers"—to American industrial executives for a period of practical trial in use.

"The arbitrary and haphazard selection of sizes which is still common practice has led to enormous wastes for everyone concerned, from manufacturer to consumer," the report states, "but the scientific basis for sizes which is now offered to industry can effect the same savings in almost every industry, which have been achieved in the automobile industry through reduction in number of styles. The consequent economies of mass production and interchangeability of parts have made tremendous reductions in price possible."

The progression of sizes from the smallest to the largest, scientifically, rather than by chance, and the elimination of slight differences for which no need exists, is the purpose of the "preferred numbers." The application of this principle to manufacturing where insignificant differences in size are continually found, even in articles of large dimensions, would simplify manufacture, distribution and purchase, the report says. The manufacturer could use fewer machines and apply the principles of mass production with resultant economy. The distributor, needing fewer sizes in his stock, could reduce his inventories and sales costs, and effect numerous attendant economies. The consumer, not faced with slight differences whose purpose he cannot understand or utilize, would find his buying problems simplified, and he would be able to replace worn-out or defective materials far more easily than at present.

Sizes are increased by a fixed percentage under the system of preferred numbers. Thus, if six curtain rods from one foot to ten feet in length, inclusive, are needed, the sizes would be 1, 1.6, 2.5, 4, 6 and 10 feet respectively, each being sixty per cent larger than the next smaller. The same numbers could be used for still larger sizes. Thus, for rubber tubing the standard lengths might be 10, 16, 25, 40, 60 and 100 feet. Larger and smaller numbers are readily obtained by a shift of the decimal point. Likewise, sizes can be spaced close together or far apart, by having 5, 10, 20 or 40 steps between 1 and 10 or between 10 and 100, as the needs of each case may require. The nationwide adoption of this system would increase the degree of interchangeability among goods manufactured in different parts of the country.

Wisconsin Rural Electric Fellowship Awarded

THE University of Wisconsin feels particularly fortunate in having secured J. P. Schaezner to carry on the work of its rural electrification fellowship. This position was recently left open when W. C. Kreuger resigned to take up rural electrification work in New Jersey.

Mr. Schaezner is a graduate in agriculture from the University of Wisconsin and has done considerable work toward his master's degree. In addition he has thirteen years of teaching experience in rural and vocational agricultural schools, and in agricultural extension and organization work. Much of his training has been in engineering and he has studied the application of electricity to agriculture.

New A.E.S.C. Chairman

THE election of William J. Serrill, of the United Gas Improvement Company, Philadelphia, to the chairmanship of the American Engineering Standards Committee is announced by the Committee. The vice-chairman during the coming year will be Cloyd M. Chapman, engineering specialist of New York City. The secretary of the Committee is Dr. P. G. Agnew, and the headquarters are at 29 West 39th Street, New York.

New A.S.A.E. Members

Harold T. Baker, assistant state extension engineer, University of Nebraska, Lincoln, Neb.

Maybin S. Baker, agronomist, U. S. Department of Agriculture, Office of Experiment Stations, Christiansted, St. Croix, Virgin Islands, U.S.A.

Geo. P. Clements, agricultural economist, Los Angeles Chamber of Commerce, Los Angeles, Calif.

George E. Grunewald, agricultural engineer, Iowa Railway and Light Corp., Blairstown, Ia.

Sydney M. Hendrickson, instructor in agricultural engineering, University of Saskatchewan, Guernsey, Sask., Canada.

A. Jensen, designing and consulting engineer for dairy equipment, Los Angeles, Calif.

Harry D. Kinney, engineer, Harvey Fisk & Sons, 120 Broadway, New York.

Eber B. Lewis, field engineer, University of Nebraska, Lincoln, Neb.

Stanley W. McBirney, assistant agricultural engineer, U.S.D.A. European Corn Borer Control, 615 Front St., Toledo, Ohio.

Curtis L. Mosher, assistant federal reserve agent and economist, Federal Reserve Bank of Minneapolis, Minneapolis, Minn.

Willard J. Parvis, agricultural engineer, U.S.D.A. European Corn Borer Control, 615 Front St., Toledo, Ohio.

Frank L. Skelton, engineer, Continental Manufacturing Co., Springfield, Ohio.

John B. Woods, assistant in engineering research, U.S.D.A. European Corn Borer Control, 615 Front St., Toledo, Ohio.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the May issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Robert C. Burnette, extension instructor in rural engineering, Cornell University, Ithaca, N. Y.

Jehan d'Etigny, manager, Compania Agricola de Vallenar, Vallenar, Chile.

Clyde R. Higgins, assistant to general agent, California-Oregon Power Company, Medford, Ore.

Eugene N. Gatlin, rural service specialist, Texas Power & Light Co., Dallas, Tex.

Thomas A. Goodridge, manager, agricultural division, Crucible Steel Company of America, Chicago, Ill.

Albert M. Jongenees, superintendent of ranch, Alaska Packers Association, San Francisco, Calif.

Herbert F. Reinhard, chief engineer, J. B. Colt Company, New York, N. Y.

J. P. Schaezner, rural electrification specialist, University of Wisconsin, Madison.

Ralph G. Wadsworth, civil engineer, Fred H. Tibbetts, 1320 Alaska Commercial Bldg., San Francisco, Calif.

Transfer of Grade

Truman E. Henton, associate in agricultural engineering, Purdue University, Lafayette, Ind. (Associate Member to Member.)

Employment Bulletin

This service, conducted by the American Society of Agricultural Engineers, appears regularly in each issue of AGRICULTURAL ENGINEERING. Members of the Society in good standing will be listed in the published notices of the "Men Available" section. Non-members as well as members, are privileged to use the "Positions Open" section. Copy for notices should be in the Secretary's hands by the 20th of the month preceding date of issue. The form of notice should be such that the initial words indicate the classification. No charge will be made for this service.

Men Available

AGRICULTURAL ENGINEER available. Seventeen years experience in the designing and manufacture of farm tractors, motor trucks, harvesting machines, and earth-working tools. Sales experience in United States, Canada, England, France, and Italy. Write for interview. MA-132.

AGRICULTURAL ENGINEER desires position with barn equipment manufacturing company. Graduate in agricultural engineering from Iowa State College. Has had farm experience and considerable experience in designing and drafting of farm structures. Services available on thirty days notice. MA-149.

AGRICULTURAL ENGINEER, graduate in agricultural engineering, (B.S. in 1923; M.S. in 1924) desires position in experimental research work. Two years experiment station experience, five years industrial shop experience, eighteen months in employ of electric service company, one year teaching. Available upon reasonable notice. Age 27. Married. MA-142.

DESIGNING AND RESEARCH ENGINEER with experience in developing equipment and machinery for commercial field. Several years experience in commercial research. Will undertake specific projects for business desiring the solution of problems in design, performance testing, or engineering analysis. MA-145.

MECHANICAL ENGINEER with fifteen years experience in heavy line power farming and harvesting machinery, such as tractors, threshers, combines, and corn pickers and huskers, including ten years as chief engineer, desires employment with reliable and substantial manufacturer of farm equipment. Will go anywhere. MA-146.

EDITOR AND WRITER with ten years experience in farm mechanical equipment, from both trade journal and farm paper angles, specializing on promotion and technique of power farming. Qualified for publication, house organ, advertising literature, or sales promotion work involving technical accuracy and popular appeal. Farm background, college training, instructional experience. W. B. Jones, St. Joseph, Mich.

AGRICULTURAL ENGINEER desires position as general manager of large agricultural concern where initiative, ability and resourcefulness are required. Has knowledge of legal procedure and finance, has handled agricultural propositions employing three thousand men, speaks Spanish, recently carried out reorganization in Latin America for one of the largest banks in this country. Can furnish credentials as to character, integrity and sobriety. 40 years of age, excellent health, American native born, protestant, married. Will go anywhere but prefers continental U.S.A. MA-148.

MECHANICAL AND AGRICULTURAL ENGINEER, graduate of University of Michigan, with many years experience in the design, purchasing, production, manufacture, and sale of agricultural implements, iron pumps, hand and power spray machinery, and with a wide acquaintance with manufacturers, jobbers, and dealers, desires employment with a reliable and substantial manufacturer. Will go anywhere. MA-150.

MECHANICAL ENGINEER, graduate of a New England college, with twelve years commercial drafting experience, six years in college teaching, desires position in college work. Forty-two years of age; unmarried; naturalized citizen of English birth; Protestant. Available August 1. MA-151.

Positions Open

AGRICULTURAL ENGINEER with college training and practical experience with tillage tools and seeding machinery wanted by a farm machinery manufacturer in the Middle West. Must be skilled draftsman and have designing ability. PO-132.

AGRICULTURAL ENGINEER capable of designing automatic shocking machine for commercial production from a factory model that has been successfully demonstrated in the field for four years wanted at once. Wire A. L. Marks, 407 Empire Block, Edmonton, Alberta, Canada, giving full particulars as to training, experience, references, and salary expected.

THREE ENGINEERS with several years experience in tractor design wanted by old established tractor manufacturer. Interested persons should explain experience fully, salary expected, etc. PO-134.

